RAILWAY MENSURATION.

ELEMENTARY PRINCIPLES

AND

PRACTICAL RULES

FOR

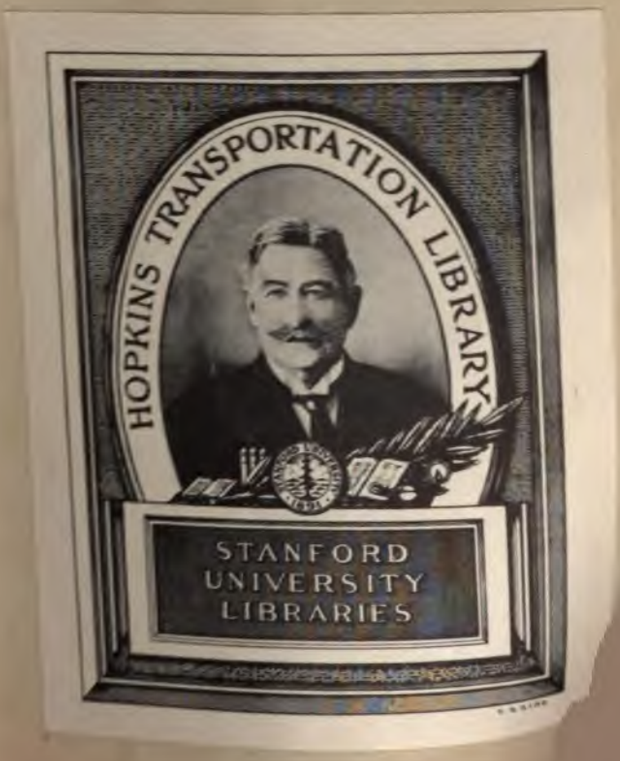
THE CALCULATION AND SETTING OUT ALL KINDS OF RAILWAY WORK.

BY EDWARD V. GARDNER, C.E.

With Explanatory Engravings of the whole.

Thomas Haines.

1848



Thomas James.

1848

AN

EASY INTRODUCTION

TO

RAILWAY MENSURATION,

ILLUSTRATED BY

DRAWINGS FROM ORIGINAL WORKS,

THAT HAVE BEEN CARRIED OUT UPON VARIOUS

ENGLISH RAILWAY LINES,

SHOWING

A PLAIN AND EASY METHOD OF TAKING OUT QUANTITIES OF EVERY DESCRIPTION OF RAILWAY WORK AND ESTIMATING THEM,

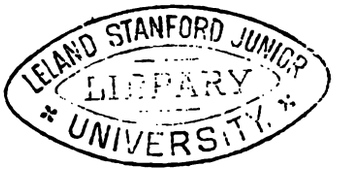
AND

SETTING OUT WORK FOR THE MAKING OF RAILWAYS GENERALLY.

BY E. V. GARDNER, C.E.

LONDON:
JOHN WEALE, 59, HIGH HOLBORN.

1847.



LONDON:
GEORGE WOODFALL AND SON,
ANGEL COURT, SKINNER STREET.

PREFACE.

THE purport of this work is to instruct the inexperienced, in a concise form, in the practical methods of taking out quantities and admeasuring railway and other works. The plans are copied from original drawings of works that have been carried out—the dimensions of the various parts are given in columns with marginal description. Parts of each are cubed and carried out, and the remainder left for the learner to cube and finish for practice. To each plan are blank ruled pages, sufficient for the student to measure such plan again, so that, by reference to the plans and the original dimensions, the whole admeasurement of each can be carried out by his own work, and thus a thorough knowledge of the various dimensions and their measurement acquired and reduced to practice.

There may be many other forms of bringing out dimensions, but the numbers of parts measured should always be placed first, to prevent error of quantity, such as occurred a few years since in the erection of a new church a few miles from London, where the gallery was measured and not twiced, thus leaving one gallery entirely out of the quantities, which could scarcely have happened had the No. 2 been placed first. In all cases, even in cubing the dimensions herein for practice, every di-

mension should be checked, to prevent error; and before beginning to measure, to well study and understand the plan.

The setting out of the railway line with curves, and the method of marking out the width of land for unsoiling, is described by figured plans, and the method of transferring the ranging line in tunnels from above to below the surface of the ground briefly explained; and care has been taken to make every part as clear as possible to the uninitiated, to whom the book is addressed, the Author satisfactorily anticipating that the young railway engineers especially will obtain much useful knowledge therefrom.

ELEMENTARY INTRODUCTION.

BEFORE entering into the practical admeasurement of the plans and works contained herein, it will be necessary to bear the following rules and tables always in mind; and although we are to suppose every one already well acquainted therewith, still they may possibly be found useful and essential here.

SIGNS AND MARKS.

+ Plus, or more. The sign of addition, as $5+6=11$
− Minus, or less. The sign of subtraction, as $20-5=15$.
× Multiply by. The sign of multiplication, as $8\times9=72$.
÷ Divide by. The sign of division, as $16\div4=4$.
= Equal to. The sign of equality, as 27 cubic feet = 1 cubic yard.
:: Proportion. The sign of proportion, as 3 : 6 :: 8 : 16.
$\frac{7}{13}$ Fraction. $\surd^2$ Square root. $\surd^3$ Cube root.

LINEAL MEASURE.

7.92 inches	1 link	lk.
12 inches	1 foot	ft.
3 feet	1 yard	yd.
$5\frac{1}{2}$ yards	1 rod, pole, or perch	rod, p.
4 poles, 100 links	1 chain	ch.
40 poles, 10 chains	1 furlong	furl.
8 furlongs, 1760 yards	1 mile	mile.
80 chains, 8000 links	1 mile.	

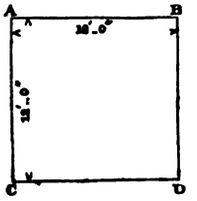
SQUARE, OR SUPERFICIAL MEASURE.

144 square inches	1 square foot.
9 square feet	1 square yard.
30¼ square yards	1 square pole or perch.
40 perches	1 rood.
4 roods	1 acre.
640 acres	1 square mile.

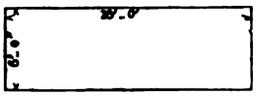
CUBIC, OR SOLID MEASURE.

1728 solid inches	1 cubic foot.
27 solid feet	1 cubic yard.

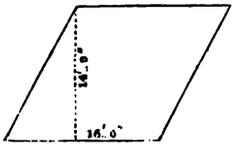
We will now proceed to the various forms of plane surfaces, and the methods of measuring them, and will begin with the



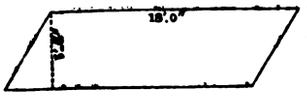
square, which hath four equal sides and four right angles, as A, B, C, D. Rule. — Multiply the given side by itself, and the product is the area required. Ex. $12 \times 12 = 144$.



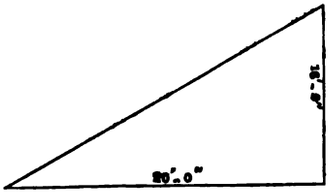
The next figure will be a parallelogram, or oblong square. Rule.—Multiply the length by the breadth, and the product gives the area. Ex. 18′ 0″ × 6′ 0″ = 108′ 0″.



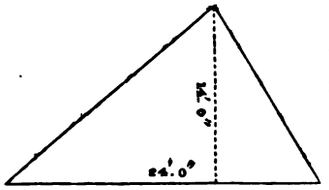
The next figure will be a rhombus, which has four sides all equal, but no right angle. Rule.—Multiply the base by the perpendicular height, and the product is the area. Ex. 16′ 0″ × 14′ 0″ = 224′ 0″.



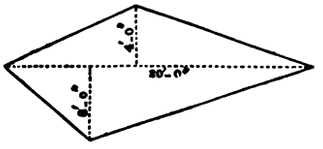
The next figure will be the rhomboides, which has its two sides equal and parallel, but no right angle; it is a long square pushed aside. Rule.—Multiply the longer side by the perpendicular height or breadth, the product is the area. Ex. 18′ 0″ × 5′ 6″ = 99′ 0″.



The next will be a right-angled triangle, having one of its angles a true square, or just 90 degrees. Rule. — Multiply one of the legs forming the right angle by half the other, the product is the area. Ex. 16′ 0″ ÷ 2 = 8′ 0″ × 20′ 0″ = 160′ 0″.

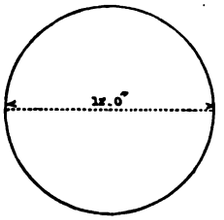


The next figure will be a triangle. Rule.—Multiply the longest side by one half the perpendicular, and the product is the content. Ex. 14′ 0″ ÷ 2 = 7′ 0″ × 24′ 0″ = 168′ 0″, area required.

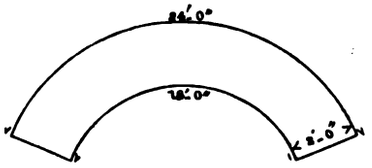


The next figure will be the trapezium, which consists of four unequal sides, and four unequal angles; it is, indeed, two triangles, and may be measured at twice, as shown in the preceding triangle, or by this Rule.—Multiply the diagonal by one-half the sum of the two perpendiculars. Ex. 8′ 0″ + 4′ 0″ = 12′ 0″ ÷ 2 = 6′ 0″ × 20′ 0″ = 120′ 0″, the area required.

The next figure will be the



area of a circle. Rule.—Square the diameter, and multiply that product by .7854, a decimal, and that product will be the content. Ex. 12′ 0″ × 12′ 0″ = 144′ 0″ × .7854 = 113.0976.



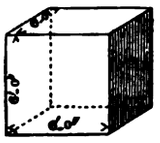
Our next diagram will be a segment or part of a section of a circle, to measure which, multiply half the sum of the two arches by one of the ends, and the product will give the area. Ex. 24′ 0″ + 18′ 0″ = 42′ 0″ ÷ 2 = 21′ 0″ × 2′ 0″ = 42′ 0″, the area required.

Where the figure be found of the shape annexed, with two right angles and the sides not parallel, instead of dividing it and measuring it as a parallelogram and an angle, take the mean of the two perpendiculars, and multiply by the length, the product will give the area required. Ex. 12′ 0″ + 8′ 0″ = 20′ 0″ ÷ 2 = 10′ 0″ × 32′ 0″ = 320′ 0″.

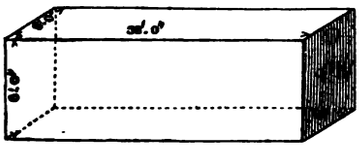
Note.—In all cases of irregular-shaped superficies, they must be reduced to the shapes of the above diagrams, and measured accordingly, as follows. Suppose the face of an embankment thus :—

				Mean height.	Area.
	′ ″	′ ″	′ ″	′ ″	′ ″
Ex. A as above,	5 0 +	8 0 =	13 0 ÷ 2 =	6 6 × 20 0 =	130 0
B ditto.	10 0 +	5 0 =	15 0 ÷ 2 =	7 6 × 18 0 =	135 0
C see 2d diag.	10 0 ×	22 0	. . .	. =	220 0
D see right-ang.	10 0 ÷	2 0 =	5 0 .	. × 44 0 =	220 0
E see triangle	6 0 ÷	2 0 =	3 0 .	. × 18 0 =	54 0

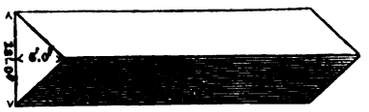
Now that we are perfectly conversant with the preceding diagrams, and admeasurement of superficial surfaces, let us proceed and take into consideration the method of measuring solid or cubic bodies; and here we will begin with a cube, viz., a solid bounded by six square sides, in the form of a die.



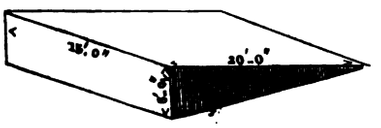
Rule.—Multiply the side by itself, and that product by the side again, the last product will be the solid content. Ex. 6′ 0″ × 6′ 0″ = 36′ 0″ × 6′ 0″ = 216′ 0″ cubic feet.

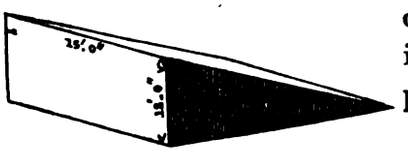


The next figure is the parallelopipedon, or oblong cube. Rule.—Multiply the breadth by the depth, and that product by the length, this last product will be the content. Ex. 6′ 0″ × 8′ 0″ = 48′ 0″ × 32′ 0″ = 1536′ 0″.



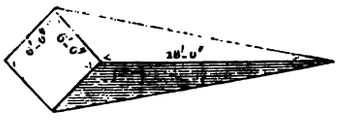
We now come to the prism, to measure which find the area at the end, multiply that by the length, and that product is the content. Ex. Perpendicular height 6′ 0″ ÷ 2 = 3′ 0″ × 12′ 0″ = 36′ 0″ × 32′ 0″ = 1152′ 0″.





The inclined plane and wedge may be measured by the same rule as the prism, but the readier way is to multiply one-half of the thickness of the base by its width, and that by the perpendicular or length. Ex. 3′ 0″ × 15′ 0″ = 45′ 0″ × 20′ 0″ = 900′ 0″, content of inclined

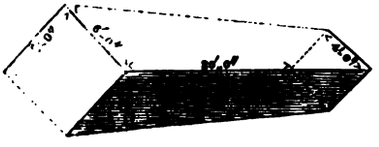
plane. NOTE.—This figure will be found in all earth-work, passing from cutting to embankment. Again, 6′ 0″ × 15′ 0″ = 90′ 0″ × 20′ 0″ = 1800′ 0″, content of the wedge.



The next figure is a square pyramid, and the one-half of which is a very prominent formation in banks, and is measured by multiplying the area of the base by one-third the height or length. Ex. 6′ 0″ × 6′ 0″ = 36′ 0″ × 6′ 0″ = 216′ 0″ content.

We now arrive at the cylinder, which is measured by multiplying the area of the base or end by the length. Ex. 12′ 0″ × 12′ 0″ = 144′ 0″ × .7854 = 113.0976 × 20′ 0″ = 2260′ 0″.

The cone is also measured by multiplying the area of the base by one-third the perpendicular height. Ex. 12′ 0″ × 12′ 0″ = 144′ 0″ × .7854 = 113′ 0″ × 6′ 8″ = 753′ 4″.



Our next figure is the frustrum of a square pyramid, which also is a form peculiar in embankments and cuttings. Rule.—To four times the area of the mean base add the area of each end, which divide by 6, multiply the product by the length,

you will find the contents. Ex. $4'\ 0'' + 6'\ 0'' = 10'\ 0'' \div 2 = 5'\ 0''$, the mean height of the base or thickness will be $5'\ 0''$; $5'\ 0'' \times 5'\ 0'' = 25'\ 0'' \times 4'\ 0'' = 100'\ 0'' + 36'\ 0'' = 136'\ 0'' + 16'\ 0'' = 152'\ 0''$; $152'\ 0'' \div 6'\ 0'' = 25'.4'' \times 20'\ 0'' = 506'\ 8''$, content.

NOTE.—The same rule applies to the frustrum of a cone.

Having now made ourselves quite perfect in the foregoing rules, and the method of admeasurement of the various diagrams preceding, and the elementary principles of mensuration, we may venture at once upon the admeasurement of the earth-work in the following sections.

RAILWAY.

CONTRACT.

SPECIFICATION TO CONTRACT *for the construction of that portion of the Railway extending from a point in Field No. , in the Parish of , near , to a point in Field No. , in the Parish of , near the Turnpike Road from to , including the Tunnel, being a distance of about miles, chains, and called Contract No. .*

THIS Contract comprehends the construction and maintenance of all the tunnelling, earth-work, buildings, waterways, roads, level crossings, drains, fences, and all other works, whether temporary or permanent, which may be necessary, according to the following specification and the drawings attached to it, for the entire completion, including the ballasting, ready to receive the permanent way, (but exclusive of the permanent way itself,) of the portion of the railway between the points No. , parish, and No. , parish above named, being a distance of about miles and chains, more or less,

the whole for one gross sum, and also such other extra work as may be required by the engineer, and ordered by two of the Directors in writing, the same being paid for in addition to the gross sum, as hereinafter provided for extra works, the whole, whether contract work or extra work, being subject to all the terms and conditions of the following specification.

CUTTINGS.

CROSS SECTIONS.

1. The cuttings will be formed according to the cross sections referred to on the longitudinal section, subject to the following rules and modifications.

MATERIALS NOT TO BE REMOVED.

2. No materials whatever obtained in the excavation shall be removed or used by the contractor, otherwise than in the construction of the works, without the sanction of the engineer; and no material, whether top soil or other excavation, set aside temporarily on land not belonging to the company, shall be allowed to remain after the completion of the works, but shall be used in soiling the slopes to an increased thickness, or carried to embankments or permanent spoil; or if so left, the sum of one shilling and sixpence per cube yard upon all such material shall be charged against the contractor in the settlement of accounts.

EMBANKMENTS.

3. The embankments will be formed according to the cross

sections referred to in the longitudinal sections, subject to any of the preceding or following rules or modifications.

FORMING SLOPES.

4. The surface of the embankments, unless when they consist of rock, or other materials which in the opinion of the engineer do not require such precautions, shall from the commencement at all times be kept thoroughly drained, and any hollows arising from settlement or other causes shall immediately be drained and then filled up, and every other precaution taken to prevent any surface water collecting and soaking in; and when the period shall arrive for laying on the permanent ballast, which shall not be done until the embankment has been allowed to settle as long as the time fixed for the completion of the several parts of the contract will permit, the surface shall be carefully trimmed to the required shape, and the lumps broken, if the materials are soft, and all loose materials trodden or beaten in, and generally all means taken to form a solid smooth surface, of the form shown in the cross sections, or all similar precautions taken to prevent such surface being injured as are referred to under the head of Cuttings.

BALLASTING.

QUALITY OF BALLAST.

5. Should good fine gravel for the upper surface be found within a distance of six miles upon the line of railway, but which cannot be obtained until after the permanent way is laid, the contractor, by special permission from the engineer, may at first ballast the lower twelve inches with broken stone or cinders, or slag, and afterwards complete the required quantity by such gravel.

MATERIALS.

BRICKS.

6. The bricks are to be full sized, making nine inches in length with a thin joint, sound, well burnt, and well shaped, and equal to the best quality of the bricks made at .

LIME.

7. The lime is to be of the best quality of that commonly known as stone lime, or other good lime that may be approved of by the engineer.

SAND.

8. The sand is to be clean sharp sand, free from any vegetable substance, and well screened, if required, through a screen of not less than four meshes in the inch. If ashes are used, they must be clean well burnt furnace ashes.

MORTAR.

9. The mortar is to consist of one portion of lime, measured dry, and two and a half of sand or ashes;—the lime to be carefully screened and slacked, and to be thoroughly mixed with the required proportions of sand or ashes and water, in a pug-mill or under edge-stones,—and no water shall be added afterwards; and every precaution shall be used to insure the best mortar. Whenever the circumstances of the work shall appear to the engineer to require it, edge-stones shall be provided, and used for the mixing of the mortar. In all foundations, and wherever the work will be exposed to wet or damp, hydraulic lime or Roman cement shall be used.

ROMAN CEMENT.

10. The cement is to be of the best quality, and from manufacturers approved of by the engineer, to be used fresh, and to be well mixed with sand, in such small quantities as may from time to time be required, in the proportion of one of cement to one and a half of sand. No water on any account to be added after it has been once mixed; and no cement to be used or mixed up with any other cement after it has once begun to set.

CONCRETE.

11. The concrete is to consist of five parts of clean gravel, perfectly free from loam or clay, with a proper proportion of small gravel and sand, as well as large, and one part of water, lime measured dry; the lime to be thoroughly mixed with the gravel and water.

STONE IN COPING AND STRING COURSES AND IN RUBBLE WORK.

12. The stone for copings and string courses to be of the best quality of , sandstone, or other stone of equal quality, and approved of by the engineer, to be clean, of good colour, and free from cracks and all other defects.

The stone for rubble work shall be equal to the best sandstone, or to the best lias, free from water-joints, flaws, and other defects, and selected only from such beds as will stand the weather.

TIMBER.

13. All the timber, unless otherwise specified in the particular description of the building, used in the permanent construction of any buildings, is to be yellow pine, Quebec or

Upper Port growth, of the best quality, straight, sound, strong, and free from all defects, and creosoted under pressure, according to the ordinary process of creosoting in use on the Great Western Railway, and not less than thirty-five gallons of genuine creosote is to be forced into each load of timber; and the timber is to be creosoted after it has been converted and fitted together, and all the holes bored in it.

CAST IRON.

14. All cast iron required for girders, caps, sockets, and other parts to be of the best material, clean, sound, and well shaped; castings of the full size and dimensions shown on the drawings.

WROUGHT IRON.

15. All the bolts, straps, pile-shoes, pile-rings, spikes, plates, nails, and other wrought iron, must be scrap or cable-iron, or No. 3, as suited to the particular case, and of the best quality and workmanship.

QUALITY OF ALL MATERIALS TO BE APPROVED BY THE ENGINEER.

16. Generally, all materials to be used in the works shall be of quality approved of by the engineer; and any materials which may not be so approved shall, upon his order, be immediately removed from the works; and if the contractor shall fail to comply immediately with such order, the engineer may remove them at the contractor's expense, deducting the amount of all the costs consequent on such removal from the next or any subsequent payment.

WORKMANSHIP.

BRICKWORK.

17. The brickwork, where used, shall be bedded sound, and in setting the bricks of arches, they are to be well pressed into their bed, so as to squeeze the mortar out of the joints, and leave the joint thin; the mortar to be used sufficiently thin in the interior of all works to enable the workmen to flush up the joints full and sound, without grouting, and particularly without striking the bricks, &c.; and no grouting whatever shall be used in any part of the works, unless especially directed by the engineer.

BRICKS TO BE WELL BONDED AND WORK POINTED.

18. The bricks in each course to be well bonded, and the different courses to cross-joint, so as to make the most sound and perfect work; all joints to be kept as thin as possible, consistently with making sound work; and all exterior joints are to be well pointed with mortar or Roman cement, (according to the material in which the work has been laid,) prepared for that purpose.

NO BATS TO BE USED.

19. No bats to be used, unless where it may be necessary for obtaining the required dimensions of the different courses.

UPPER COURSES SET IN CEMENT.

20. All those parts of the brickwork distinguished in the drawings by colour or by writing as cement, shall be set in Roman cement, as well as the upper course of the brick cor-

nices, plinths, or offsets of every sort, which are exposed to the weather.

MASONRY TO CONSIST OF FITTED RUBBLE.

21. The masonry is to consist (everywhere except in copings and string courses, and unless when any other sort of masonry is especially provided for as an exception, and as in lieu of this,) of good rubble work, to be called "fitted rubble;" no face-stone shall be less than eight inches in depth, or less than two feet in content, and laid on its natural bed; the faces shall be selected or rendered flat, so as to form a good uniform flat exterior surface to the work, of uniform colour, and free from all clay and iron stains, and the stones shall be selected or prepared, so as to fit well upon and against each other, and to require only thin joints of mortar; in the backing, less fitting will be required, but in all cases each stone must be well bedded, whatever its form, with spawls or smaller stones, carefully selected, to fill in and fit the shapes of the larger stones, so as to avoid all thick mortar joints; the mortar must be used sufficiently thin to ensure the joints being as well filled as if grouted. The face-stones must all be well bonded into the backing, and all arch-stones must be prepared with a flat bed for the entire depth of the arch, and must be set carefully with thin joints.

After the work is finished, the joints shall be well raked out in the face and pointed with mortar, prepared for that purpose with clean and well burnt ashes, or in such other manner as the engineer may direct.

DIMENSIONS AND MODE OF FIXING COPING.

22. Stone coping and string courses will be introduced where shown on the drawings; the coping is to be in lengths of not less than two feet six inches, and averaging three feet,

secured at the underside of the joints by a cast iron dovetailed dowel, six inches long, and one inch square at the smallest part. The dowel is to be firmly fixed by cement or lead, run in front from the upper side through a small hole for that purpose left in the centre of the joint.

BATTERING WALLS TO BE SUPPORTED.

23. In building the wing walls or any other battering walls, if materials are not at hand to fill in immediately, and if from the state of the weather, or from any other cause, the work shall be liable to droop or fall inwards at all, or alter its form, good and sufficient shores must be provided, and the walls thoroughly secured, until the backing is made good. In building retaining walls, wing walls, or any other work against a face of excavated ground, great care must be taken either to build home to the excavated face, or to fill in as the work proceeds, and to pack the space closely and solidly.

CONCRETE USED IN FOUNDATIONS WHERE REQUIRED.

24. Under any foundations, where it may be necessary from the nature of the ground, a bed of concrete shall be used, but in no case without the approbation of the engineer.

CENTERING TO BE STRONG.

25. All the centres and tressels must be of the most substantial description, and must sustain the weight of the superincumbent work without sensible flexure. Proper allowance must be made in the original form of the centre for the sinking of the arch, and great care must be taken to form true and regular curves.

CENTERING NOT TO BE STRUCK WITHOUT PERMISSION.

26. No centering must be struck and slackened at all without permission from the engineer, but no permission to that effect will relieve the contractor from the entire responsibility of the sufficiency and proper state of the work; and if any settlement should result from this or any other cause, the contractor will be required to rebuild, at his own expense, such portion of the work as may have been so damaged.

SOFFITS OF ARCHES TO BE POINTED.

27. After the centering has been removed, and the mortar or cement set, all the joints in the soffit of the brickwork or masonry, as the case may be, are to be raked out, and the cavities well pointed up with mortar or Roman cement, according to the material in which that particular part of the arch has been laid.

TIMBER WORK AND PILE DRIVING.

28. All the timber work, whether whole timber or smaller scantlings, must be squared, and the arris left perfect, and must be altogether free from bruises and dogmarks, and no shaken timber will be allowed in any part of the work. The cast-iron caps, sockets, meeting plates, &c., must be carefully fitted on to the timber in their proper places. The bolt-holes throughout the work must in every case be bored of such size only that the bolts may fit without any play, and should any of the holes be bored too large, the contractor shall, at his own expense, provide bolts of a larger size that will completely fill the holes; each bolt, when screwed up against the wood, shall have a large washer; and all the bolts shall be of a proper length, so that when screwed down one washer shall be enough, and no more shall on any account be used; when

finished, no screw of a bolt shall project more than one inch beyond the surface of the nut; all joints, butts, scarfs, bearing surfaces, &c., after being well fitted, and before they are finally put together, must have a coat of tar, and the bolts and cast-iron pieces must be coated with it before driving or putting them finally into place, so as to render the contact perfect and exclude the air. Great care must be taken in cutting the struts to the right length, as no wedges or filling pieces will be allowed.

The planking of the roadways is to be of uniform thickness, and when sawn off on the outside, must present true and even lines. In the railway viaducts, every third plank at least must reach the whole width, and the others must not be less than one-third of the whole width of the viaduct; the upper side of the longitudinal beams, roadway planking, and all the timbers which will be covered with the earth, must have a good coat of creosote laid on after fixing, and before they are so covered up.

The planking will be spiked down to the timbers with ten-inch spikes, for which holes must be bored through the planking, a spike being used in every place where the planking crosses a timber. The fencing and hand-rail and work above the roadway planking is to be neatly wrought, and when completed, if not creosoted, is to be painted with three coats of lead and oil used by the Board of Ordnance, or other colour, as the engineer may direct; all the rest of the bridge shall be payed over twice after completion, and at sufficient intervals of time, to allow each coat to soak in, with creosote; any part which may be buried in the embankment must be payed over as soon as completed, that no delay may be incurred in finishing the embankment.

PILE DRIVING.

The piles must be accurately pointed, a chalk line being first struck on the two adjacent sides of the timber, to arrive at an average centre; then the point may be cut two and a half times the diameter, leaving an end at least three inches square.

The shoes must be fitted on very tight, without the least play. The dog-nails are to be countersunk, so that the heads shall not stand above the surface of the rings of the shoes; and when the shoe is thus firmly put on, the point must range true with the centre of the pile. If it shall be found necessary, a conical shoe-ring must be used, to prevent the shoe casting, as the piles must be driven to their required depth. The piles must be accurately driven in their places marked on the plan, and should any piles drive out of line, they must be drawn up and re-driven; if after they are driven accurately in place, any of the piles should be found defective or otherwise injured, they must be taken up and replaced by sound ones. No pile will be considered properly driven until a fifteen feet blow, with a monkey weighing at least fifteen hundred weight, will not drive it more than a quarter of an inch at each blow.

No pile will be allowed to be driven with a spongy or unsound head; and when the head is in any way defective, it must be sawn off, and the ring put on afresh; but if the length of the pile will not allow this, it must be drawn up, and one sufficiently long substituted for it. After the piles are properly shod and rung, they shall be inspected by the engineer or his assistant, that he may have them numbered and marked near the head, which marks shall on no account be destroyed, nor shall the part of the pile on which they are made be sawn off, unless by an express permission of the en-

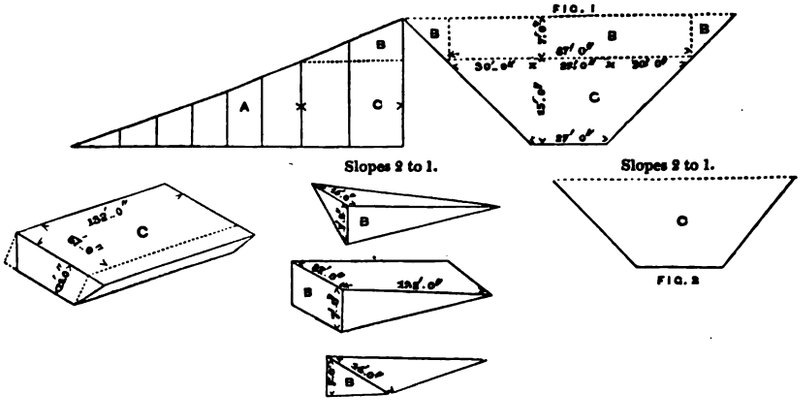
gineer; should not this be attended to in any case, the pile shall instantly be drawn and replaced by another.

IRON TO BE PAINTED.

29. All iron work, before fixing in place, shall be well cleaned of rust, and painted with not less than two coats of paint, and after being fixed shall again be cleaned, if required, and shall be painted again with not less than two coats.

MEASUREMENT OF EARTH-WORK.

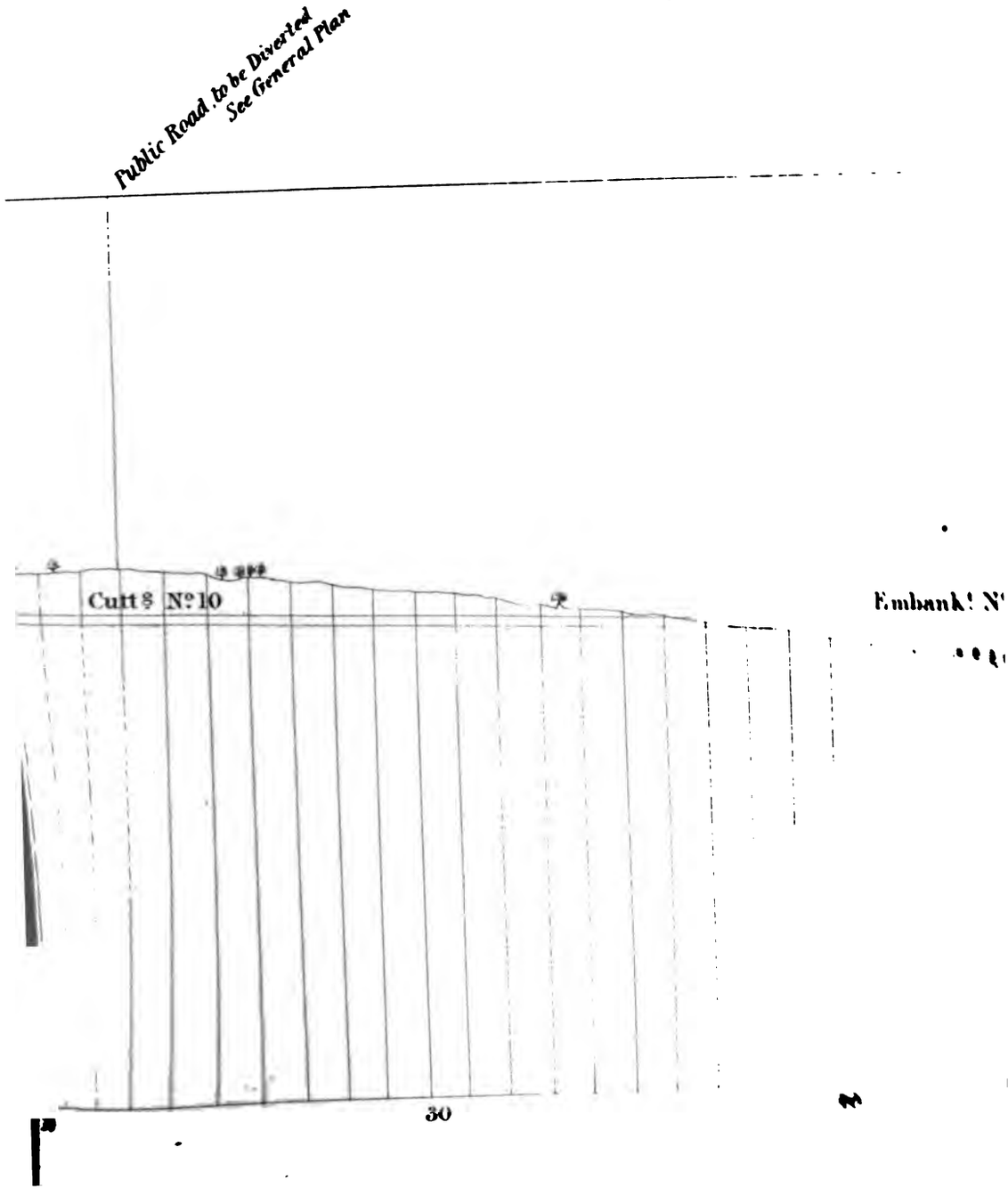
THERE are many works and tables published to facilitate the admeasurement of earth-work, which may be reduced in practice to the following geometrical forms, in one or more chains in length, as the case may be. The two chains marked B and C in the section will reduce to the forms in the diagrams that follow. The dotted lines, Fig. 1, show the section at the largest end, next to E in the section; and the dotted line, Fig. 2, shows the section at the smallest end, next to A in section.

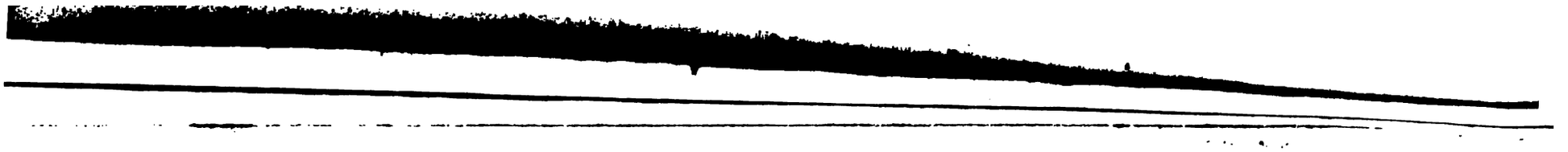


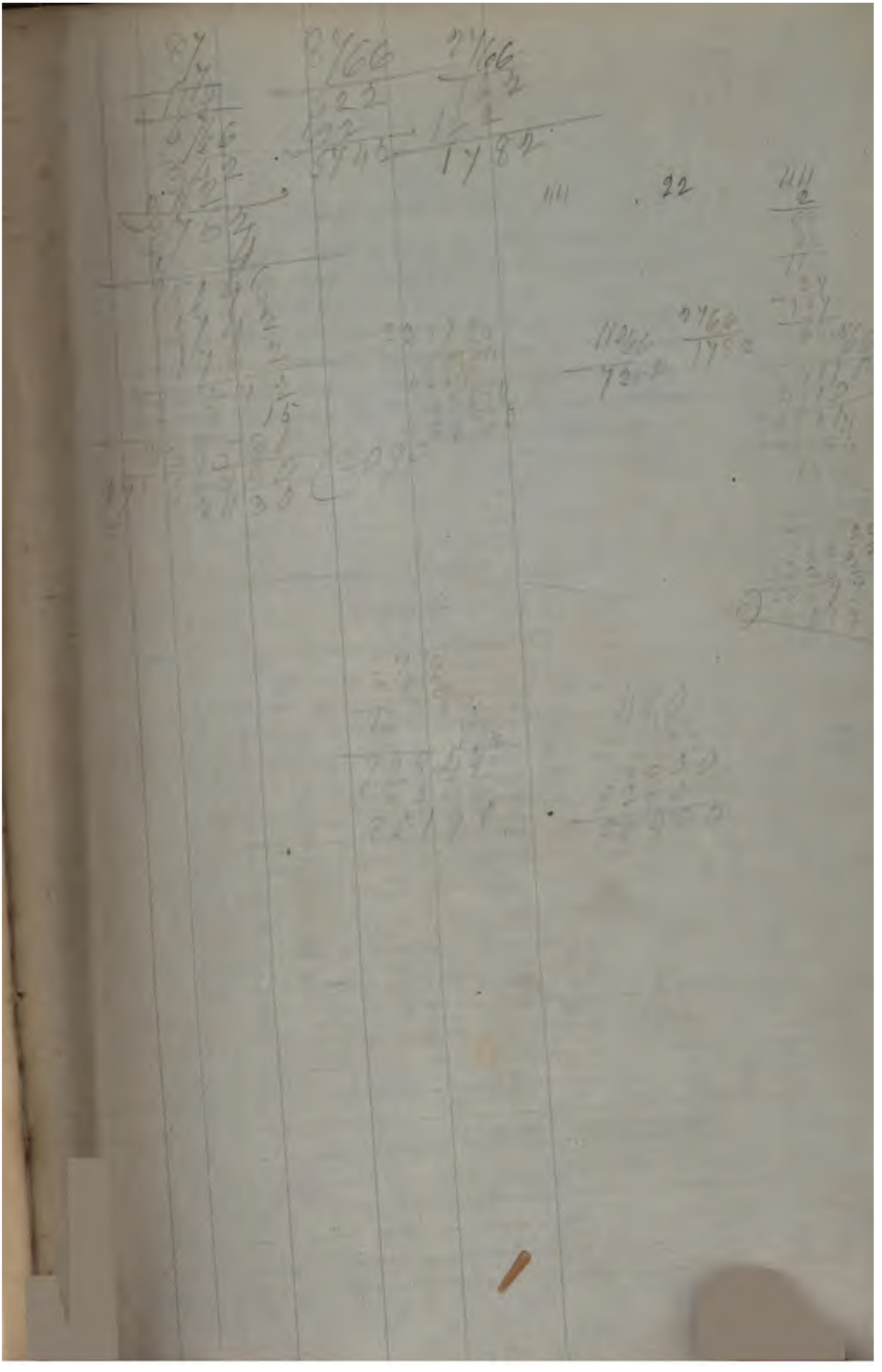
The bottom piece, C, being reduced to a parallel throughout, is measured by multiplying the area of the end by the length, —the two banks being equal it will measure thus:—15′ 0″ × 57′ 0″ × 132′ 0″.

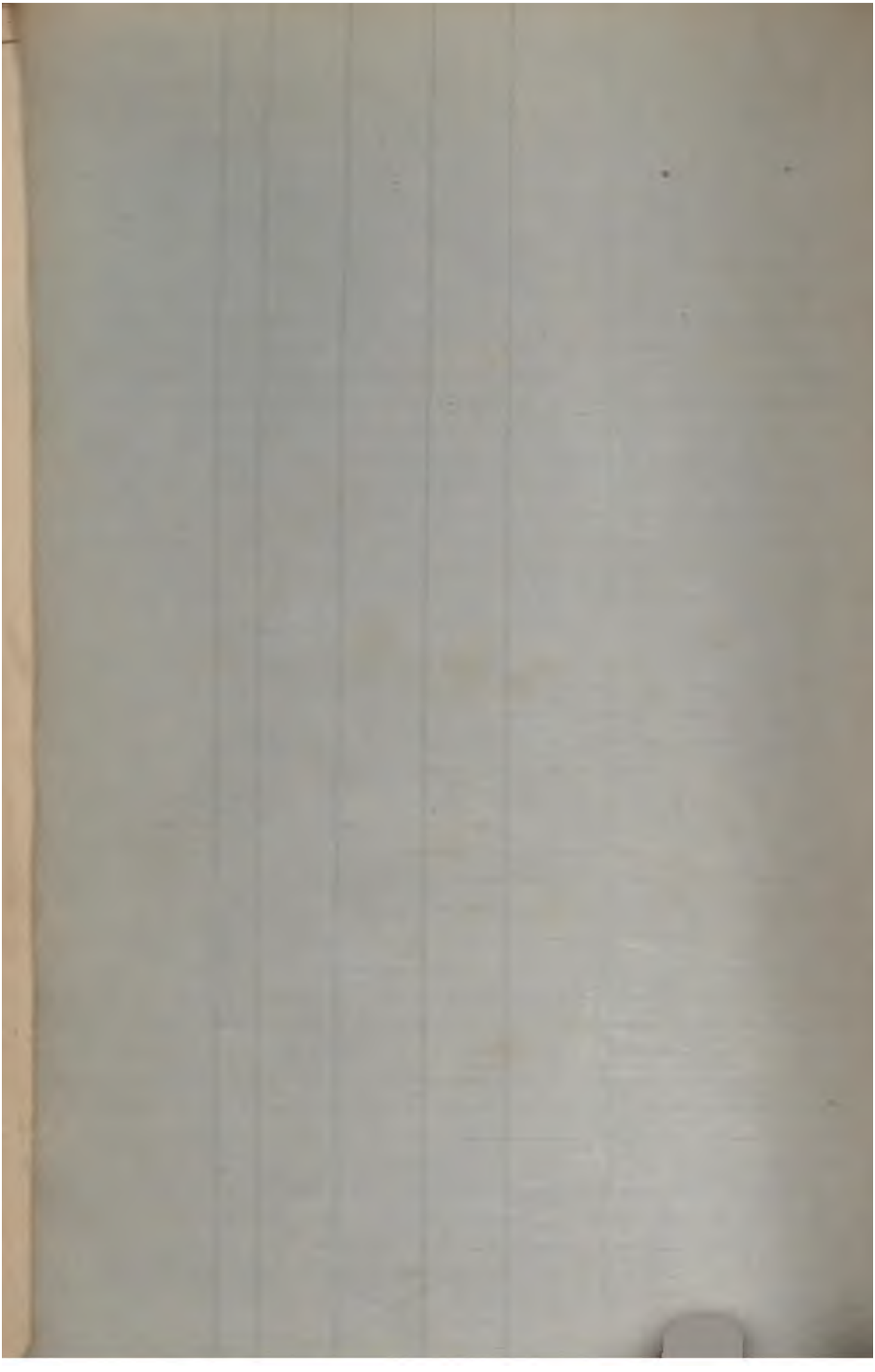
NOTE.—The dotted lines on the section C show the reduced forms for admeasurement; and in cubing earth-work, give the odd inches as one foot.

Horizontal Scale 4 Chains to 1 Inch
Vertical Scale 40 Feet to 1 Inch.


Public Road to be Diverted
See General Plan
Cutt.g N.º 10
Embank.t N.º
30







The piece B, the middle or wedge piece, being parallel horizontally only, is measured by taking one half the vertical height, thus:—3′ 6″ × 87′ 0″ × 132′ 0″.

The two pieces, B B, form the two halves of a right-angled pyramid, and are measured by multiplying the area of the end by one-third the height; therefore, 7′ 0″ × 14′ 0″, the slope being 2 to 1, is equal to 98′ 0″; the area of the two bases then, 1′ 0″ × 98′ 0″ × 44′ 0″, gives the cube quantity in the two.

LONDON AND BRIGHTON RAILWAY.

KEYMER BRANCH.

CUTTING No. 9.—Slopes 2 to 1.

EARTH-WORK, Surface Level, 27 feet.

No.	′	″	′	″	′	″	Cubic feet.	
1	7	6	27	0	396	0	80190	A
	1	0	450	0	132	0	59400	A
	3	6	87	0	132	0	40194	B
	1	0	98	0	44	0	4312	B
	15	0	57	0	132	0	112860	C
	1	0	113	0	198	0	22374	D
	1	0	8	0	66	0	528	D
	21	6	70	0	198	0	297990	E
	23	0	73	0	66	0	110814	F
	1	3	115	0	132	0	18975	G
	1	0	12	6	44	0	550	G
	22	0	71	0	132	0	206184	H
	4	0	85	0	198	0	67320	I
	1	0	128	0	66	0	8448	I
	14	6	56	0	198	0	160776	K
	1	0	79	0	66	0	5214	L
	1	0	8	0	22	0	176	L
	13	0	53	0	66	0	45474	M
	6	6	27	0	396	0	69498	N
	1	0	338	0	132	0	44616	N
	1	6	33	0	99	0	4901	O
							1360794	50399$\frac{7}{27}$ cubic yards.

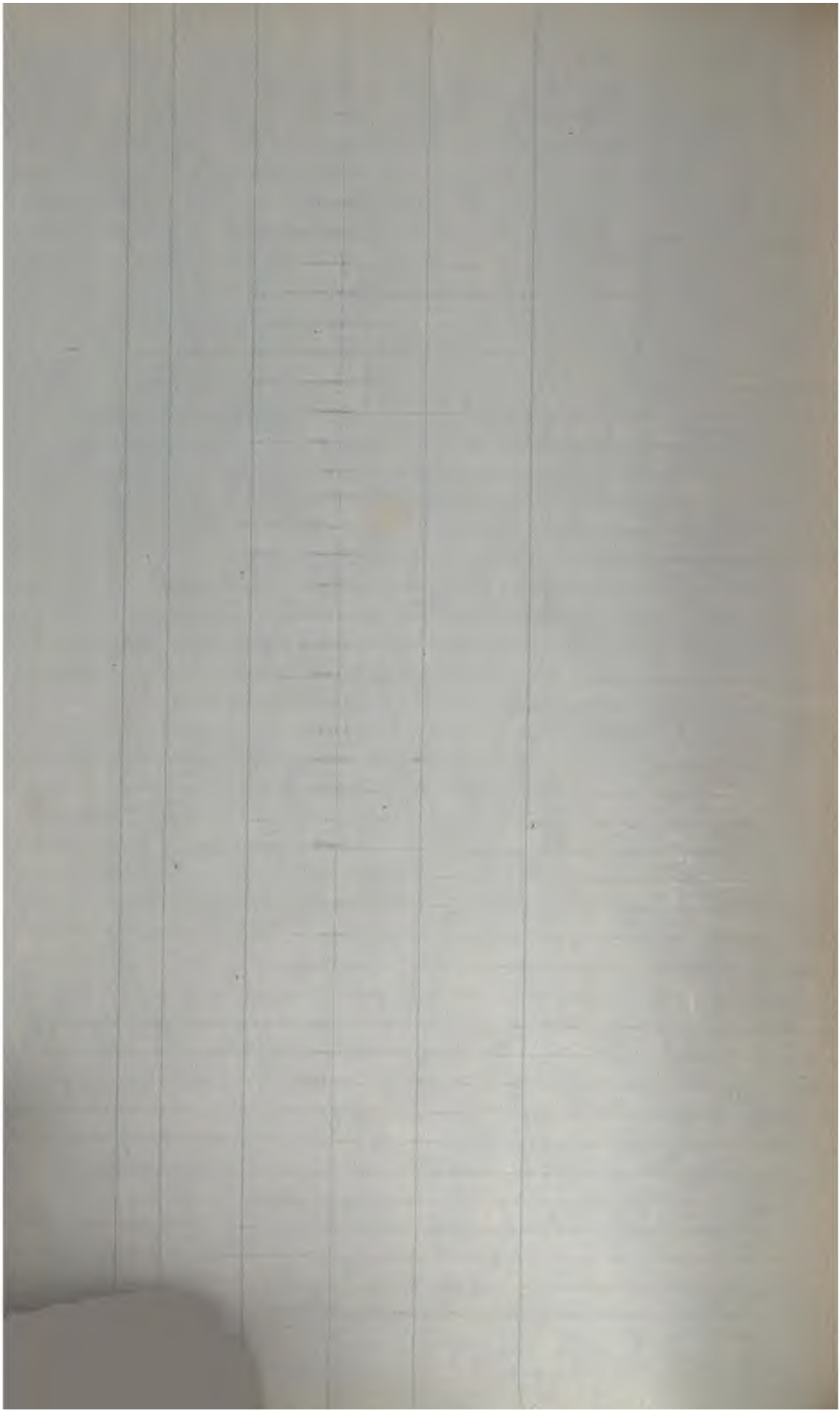
EMBANKMENT No. 10.

EARTH-WORK, continued, Surface Level, 27 feet.

No.	′	″	′	″	′	″	Cubic feet.	
1	3	0	27	0	198	0	16038	Brought forward—
	1	0	72	0	66	0	4752	50399$\frac{7}{27}$ cubic yards.
	6	0	39	0	198	0	46332	
	3	6	51	0	132	0	23562	
	1	0	98	0	44	0	4312	
	3	0	57	0	66	0	11286	
	3	0	63	0	66	0	12474	
	1	0	72	0	22	0	1584	
	4	2	27	0	88	0	9900	
	1	0	144	6	29	4	4239	
							134479	4980$\frac{19}{27}$ cubic yards.

CUTTING No. 10.

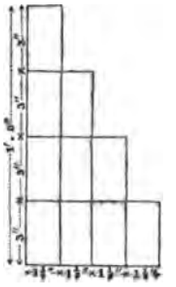
1	3	0	27	0	80	0	6480	
	1	0	72	0	26	8		
	3	0	51	0	198	0		
	1	0	72	0	66	0		
	6	0	39	0	198	0		
	1	0	90	0	198	0		
	1	0	8	0	66	0		
	1	0	90	0	132	0		
	1	0	8	0	44	0		
	12	0	51	0	330	0		
	1	0	71	0	33	0		
	1	0	8	0	11	0		
	0	6	71	0	22	0		
	1	0	3	0	7	8		
	11	0	49	0	66	0		
	1	6	65	0	132	0		
	1	0	18	0	44	0		
	9	6	46	0	132	0		
	1	6	57	0	66	0		
	1	0	18	0	22	0		
	7	6	42	0	198	0		
	1	6	47	0	99	0		
	1	0	18	0	33	0		
	5	0	37	0	132	0		
	0	9	39	0	132	0		
	1	0	4	6	44	0		
	3	0	33	0	132	0		
	2	0	31	0	66	0		
	1	0	27	0	66	0		
	1	0	8	0	22	0		
								cubic yards.



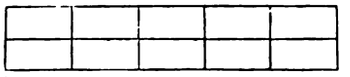
The last piece, 4 feet in height, 52 long, will be—

2 0 × 27 0 × 52 0
1 0 × 32 0 × 17 4

In the following plans the dimensions are all estimated, and the quantities are at the beginning of each section brought out, the remainder are left for the learner to cube and carry out for useful practice. By a little close inspection of the plans, and a reference to the marginal description of the various parts, a very short time will enable the learner to measure the whole, which should be done two or three times over. The plans and sections should be well understood before any admeasurement be begun, and great care taken that no part be omitted.



In taking all footings, reduce them to the easiest cube form adapted to the quantity; thus, in drawings 5 and 6, the footings are four course, projecting 1½ inches each, thus forming ten areas of 3 × 1½ each, or 45 superficial inches; now project the footing thus:—



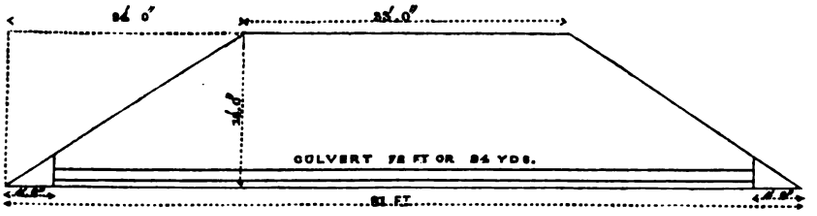
it will read 0′ 3″ × 1′ 3″ cube, being, in fact, the same quantities, but more readily cubed.

Note.—All brickwork in railway works is estimated by the cubic foot or yard. Now to reduce the cubic feet of brickwork to the standard thickness of 1½ brick, multiply by 8 and divide by 9, the standard thickness of 1½ brick, or 13½ inches, being ⅔ of one foot.

NOTE.—To find the length of Barrels of Culverts.

Figure 1, 18-inch Culvert.

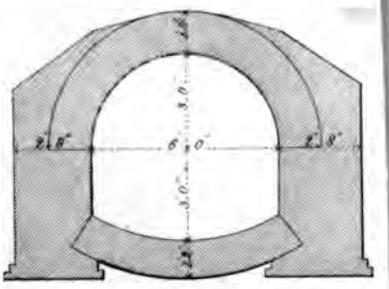
The slope to this culvert is $1\frac{1}{2}$ to 1, and the vertical height of bank 16 feet, therefore 16 and 8 is $24 \times 2 = 48$, which, added to the surface level, 33 feet, gives 81 feet for the whole width of the foot of the embankment; but the elevation of the culvert front being 3 feet, which at $1\frac{1}{2}$ to 1 will give 4 feet 6 inches each side, making 9 feet to deduct from the total length, viz., 81, leaves 72 feet, or 24 yards length of barrel of culvert required, (see below).



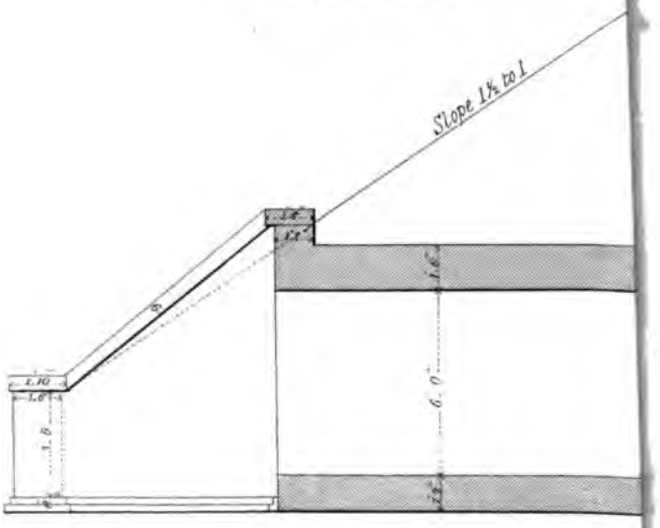
SALISBURY BRANCH EXTENSION
RAILWAY.

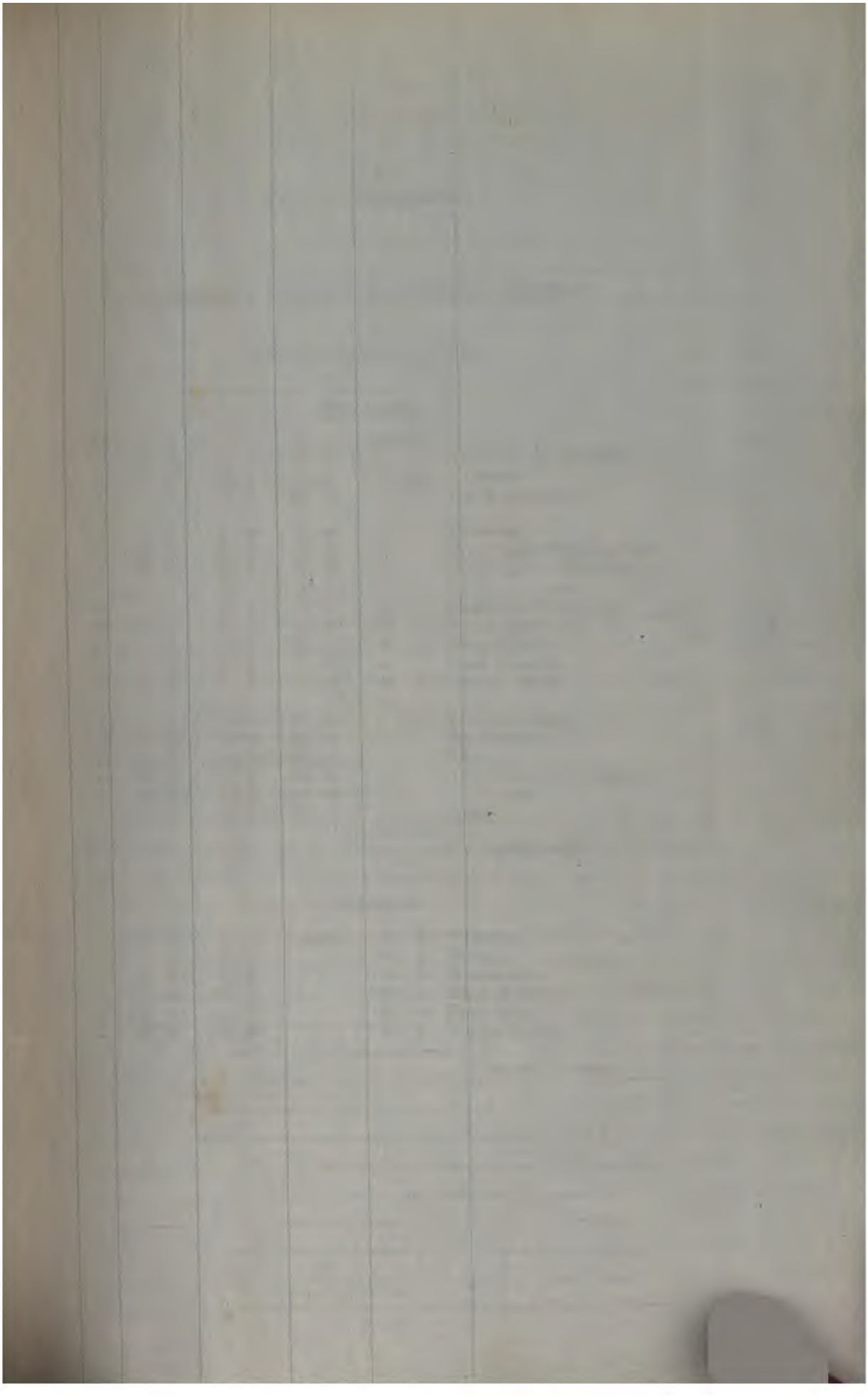
NC Nº 2

TRANSVERSE SECTION



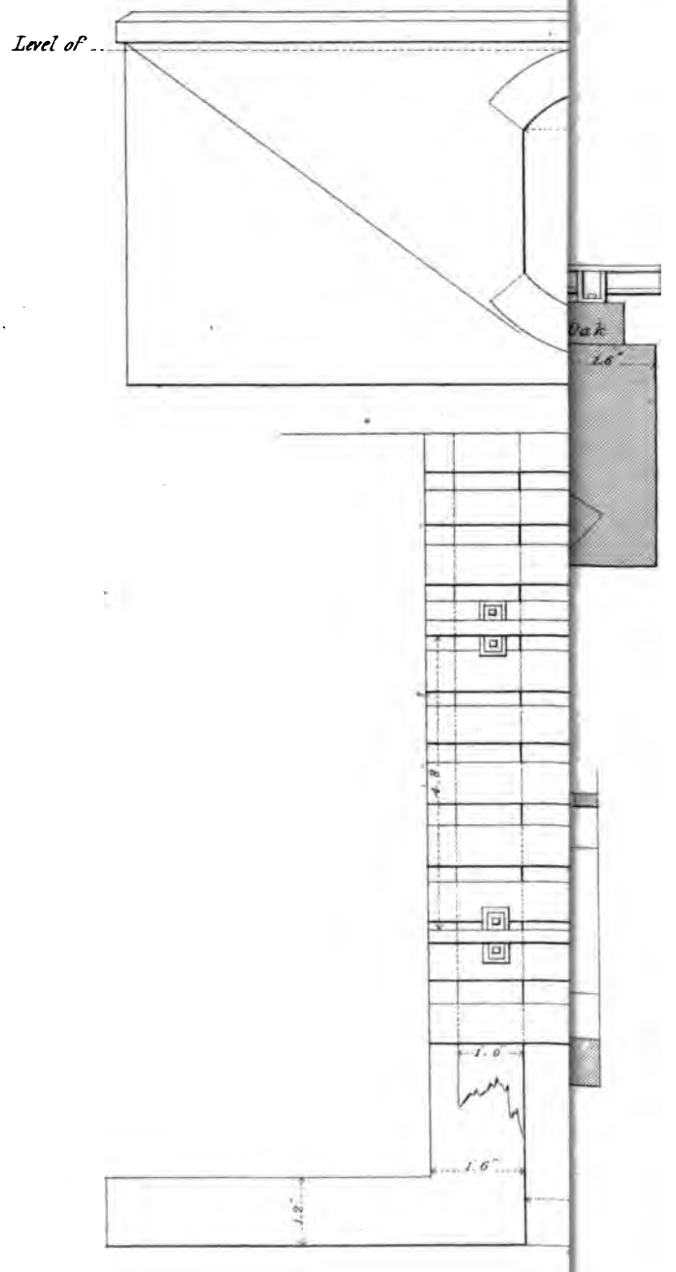
LONGITUDINAL SECTION.

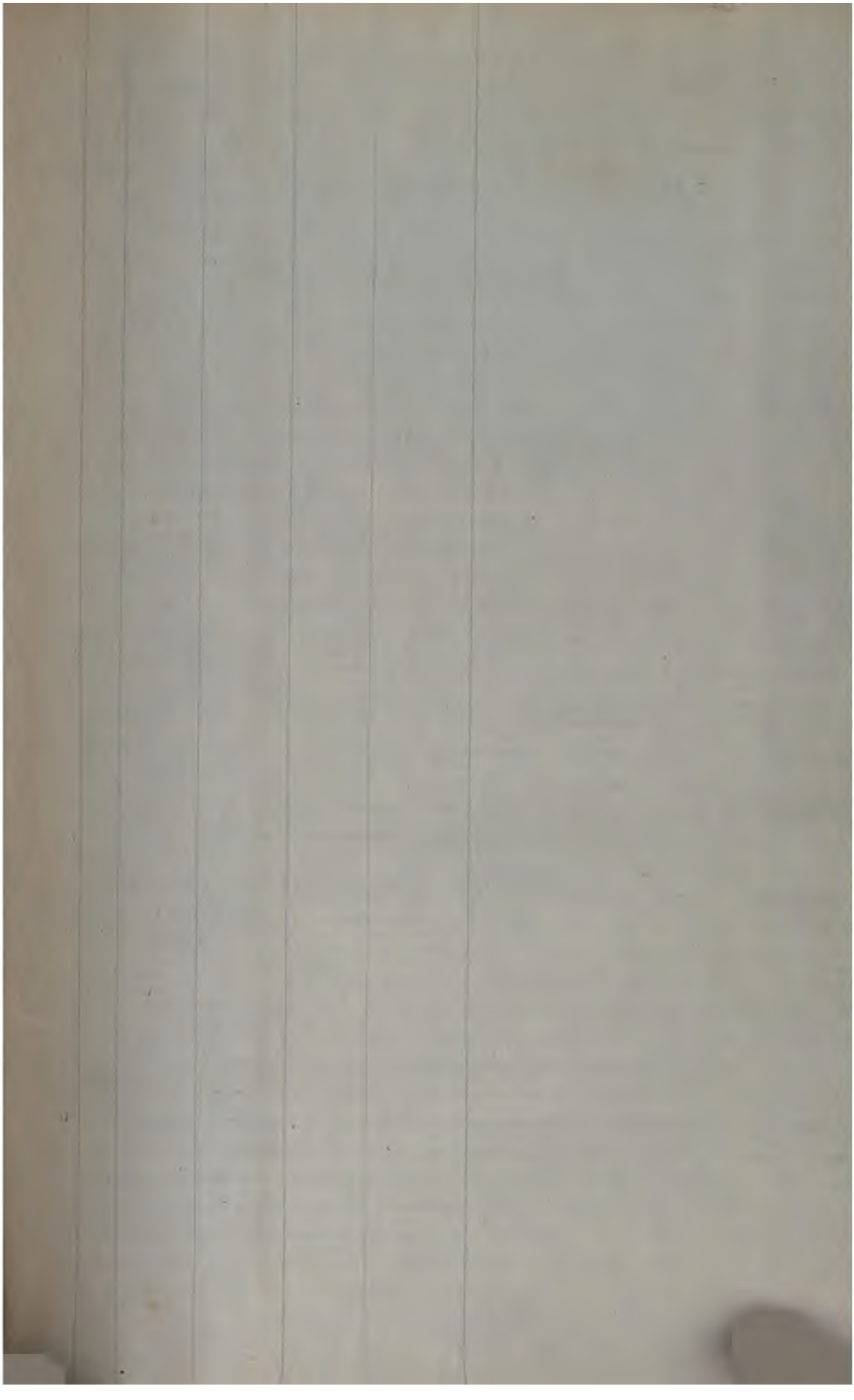




SALISBURY BRANCH EXTENSION
RAILWAY.

DRAWING Nº 3.





SALISBURY BRANCH EXTENSION.

Drawing No. 3.

Open Culvert, Figures 1 and 2.

Brickwork.

No.	′	″	′	″	′	″	Cubic feet.		
4	5	6	6	6	1	2	166	10	Elevation.
2	5	6	1	6	1	2	19	3	Do. middle pier.
4	1	7	3	0	1	2	22	2	Under-invert.
4	1	0	3	0	1	2	14	0	Arches.
3	3	9	1	6	24	0	405	0	Abutments.
2	3	8	0	9	24	0	132	0	Inverts.
1	0	6	0	3	24	0	3	0	Four spandril footings.
							762	3	cubic feet, $28\frac{6}{27}$ cub. yds.
2	6	6	4	6	superfic.		58	6	Pointing.
2	4	0	1	6			12	0	Do.
4	4	6	0	9			13	6	Do. face of arches.
							84	0	$9\frac{3}{9}$ superficial yards.

Ashlar Stone.

2	0	6	1	4	20	9	27	8	Stone coping.

Timber.

3	1	0	0	8	24	0	48	0	Oak sleepers.
25	0	8	0	2	10	6	29	6	Oak plank, 175 sup. feet.
							77	2	feet cube.

Iron.

150 eight-inch $\frac{5}{8}$ spikes . . . . . 150 spikes.

Note.—Provide for excavation, under-invert, punning, ramming, &c. —See General Specification Clause.

PORTSMOUTH EXTENSION RAILWAY.

Bridge for Stream, at 9 Miles 38.50 Chains.

Drawing No. 4.

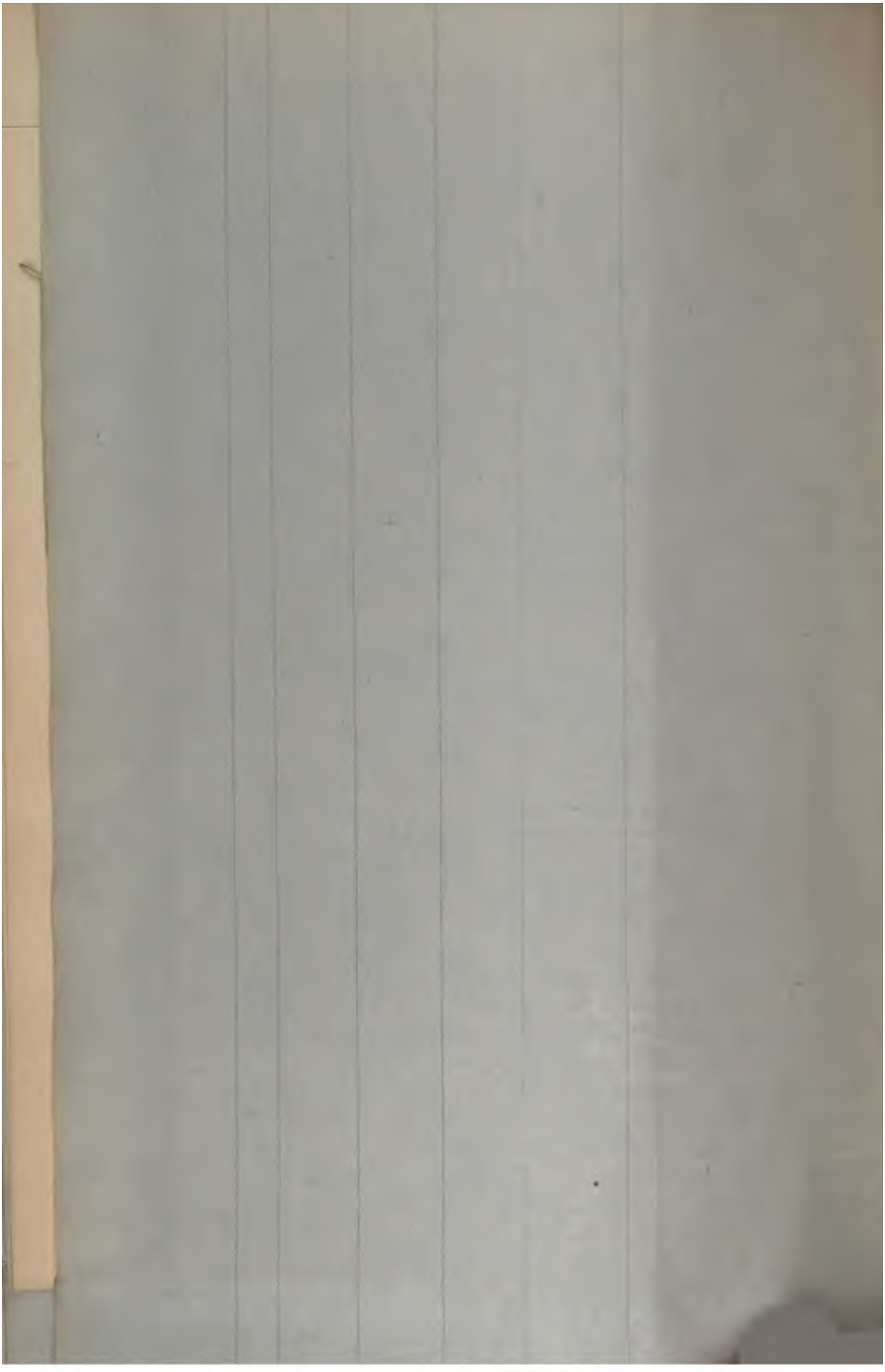
Earth-Work.

No.	′	″	′	″	′	″	Cubic feet.	
2	29	6	5	6	6	0	1947	Abutments.
4	6	0	4	9	6	0	684	Elevation.
4	4	0	3	0	6	0	288	Counterforts.
								cubic yards.

Note.—Provide for working room and sustaining slopes, also damming and pumping.—See General Specification Clause.

Brickwork.

4	0	9	0	6	29	4	44 0	Footings.
4	0	9	0	6	6	6	9 0	
4	0	9	0	6	4	3		
4	0	9	0	6	5	9		
8	0	9	0	6	3	0		
2	4	3	9	6	28	4	2287 11	Abutments.
4	3	0	3	0	9	0		Counterforts.
2	1	9	2	6	3	0		Backing to arch.
2	5	3	1	6	25	0		Arch.
2	3	9	1	2	25	0		
4	5	3	3	0	8	6	535 6	Elevation.
4	1	0	2	8	10	9	114 10	
4	1	0	2	4	15	0	140 0	
4	1	0	2	0	17	0		
4	0	9	1	2	17	0		
4	1	6	1	8	9	0		Face-ring of arch.
4	1	2	3	0	17	0		Parapets.
4	0	9	0	4½	17	4		String course.
4	0	9	0	4½	1	6		Ditto.
4	0	4½	3	0	11	0		Face of pilaster.
4	0	4½	3	0	3	0		Ditto parapets.
								cubic yards.



FARNHAM AND ALTON RAILWAY.

Occupation Road under Railway.

Drawing No. 5.

Earth-Work.

No.	′	″	′	″	′	″	Cubic feet.		
2	5	0	1	9	29	0	508	0	Abutments.
4	4	0	1	9	3	6			Counterforts.
4	5	6	1	9	5	6			Circular.
4	15	0	1	9	4	0			Wings.
									cubic yards.

Provide for securely ramming and punning at the back of arch and counterforts.—See Specification Clause.

Brickwork.

									Footings.
2	0	3	1	3	28	4	17	8	Abutments.
4	0	3	1	3	3	6	4	4	Angle return ditto.
4	0	3	1	3	3	6	4	4	Circle ditto.
4	0	3	1	3	14	3	17	10	Wing walls.
4	0	3	1	3	9	10	12	3	Pedestals.
2	0	3	1	3	7	3	4	6	Between counterforts.
4	0	3	1	3	4	0	5	0	Side of ditto.
4	0	3	1	3	4	0	5	0	Back of ditto.
8	0	3	1	3	3	0	7	6	Sides of ditto.
							78	5	$2\frac{2}{27}$ cubic yards.
2	4	0	14	3	27	4	3115	0	Abutments.
4	3	0	3	6	11	6			Counterforts.
2	0	6	2	3	3	0			Spandril to do.
1	1	6	21	3	27	4			Arch.
2	0	3	1	0	31	0			String course.
2	2	6	3	0	5	0			Spandril to abutment.
									cubic yards.

carried forward.

BRICKWORK, continued.

Brought forward, cubic yards.

No.	′	″	′	″	′	″	Cubic feet.	
4	3	0	3	9	5	6	247 6	Wing wall A B.
4	2	9	3	4	6	0		Circular work.
4	3	0	3	0	6	6		
4	2	9	2	8	7	0		
4	3	0	2	4	7	6		
4	2	0	2	0	8	0		Upper slope.
4	3	0	3	4	4	0		Wing walls, plain.
4	2	9	3	0	4	0		
4	3	0	2	8	4	0		
4	2	9	2	4	4	0		
4	1	6	2	0	4	0		Upper slope.
4	3	0	3	0	4	0		
4	2	9	2	8	4	0		
4	3	0	2	4	4	0		
4	1	4⅓	2	0	4	0		Upper slope.
4	3	0	2	8	4	6		
4	2	9	2	4	4	6		
4	1	6	2	0	4	6		Upper slope.
4	2	4	3	0	5	0		Pedestals.
								cubic yards.

ELEVATION.

4	3	0	1	6	2	0	36 0	Spandrils.
4	2	0	2	0	2	0		
2	4	0	2	0	2	0		
4	3	6	1	2	2	0		
4	7	6	0	9	2	2		Sailing course.
								cubic yards.

POINTING.

						Superfic. feet.	
4	1	0	16	6		66 0	Spandrils.
4	1	0	7	6		30 0	Sailing courses.
4	1	6	10	8		64 0	Face of arch.
4	1	6	6	0		36 0	Do. abutments.
4	1	8	1	9			String course.
4	3	0	3	6			Pedestals.
4	2	4	3	6			
1	18	10	27	4			Soffit arch.
2	28	0	1	8			String course.
2	6	0	27	4			Abutments.
							superficial yards.

Pointing, Circular and Batter, 1½ to the Foot.

No.	′	″	′	″	Superfic. feet.
4	16	0	6	9	

Batter only.

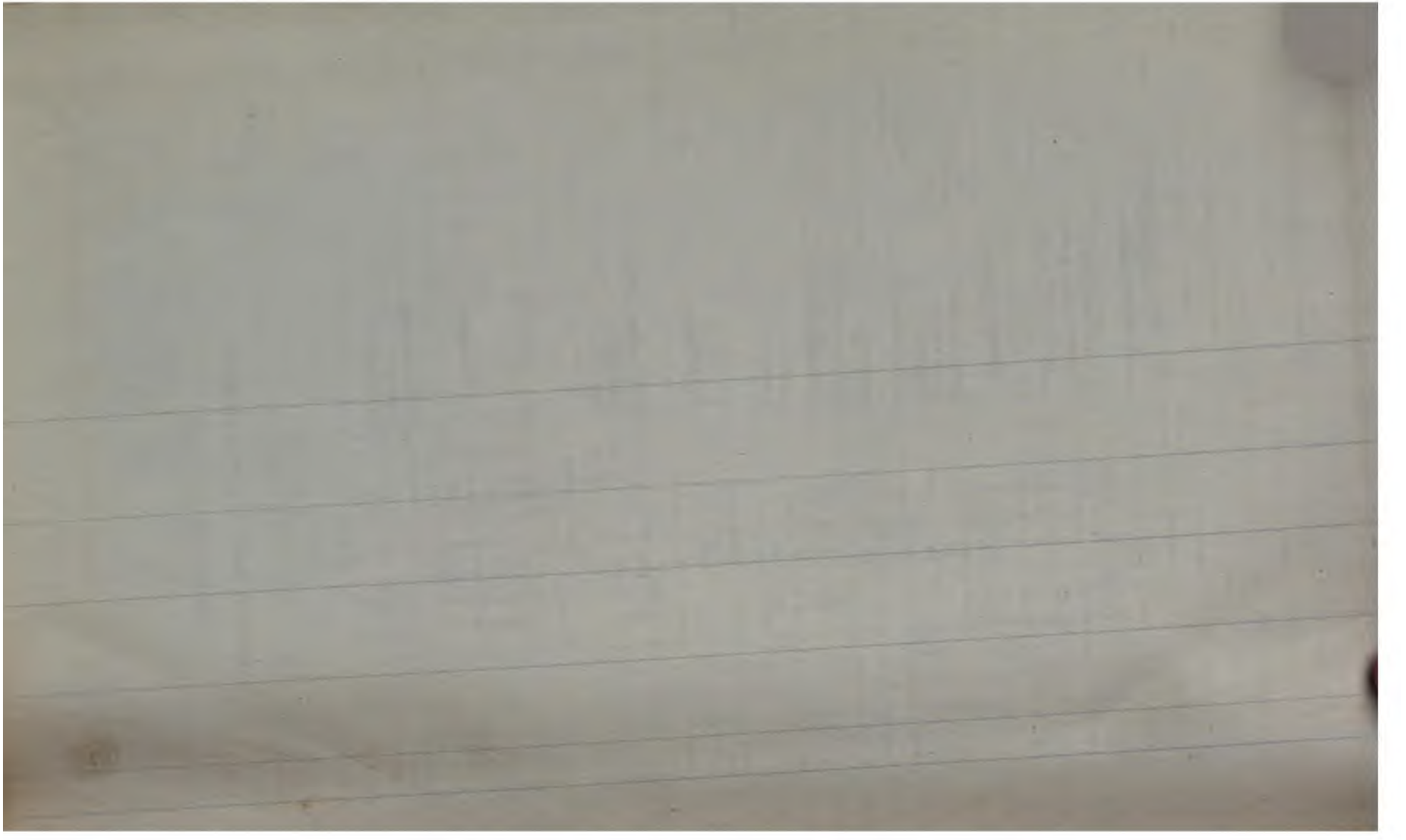
4	2	6	15	0	150 0	Wing walls.
4	5	0	15	0		Ditto.
4	1	0	12	0		Angles.
						superficial yards.

Coping, Ashlar Stone.

						Cubic feet.	
4	1	6	0	6	7 9		Elevation.
4	1	6	0	6	14 6		Wing walls.
4	2	8	0	9	3 4		Caps.
4	1	6	0	6	7 1		Circular and sloped.
							cubic feet.

Extras.

48 0 foot run of arris cutting to angles.
90 0 foot run bed, cutting wing walls under coping.
31 0 foot run, back cutting to sailing courses.



FARNHAM AND ALTON RAILWAY.

Occupation Bridge over Railway.

Drawing No. 6.

Earth-Work.

No.	′	″	′	″	′	″	Cubic feet.		
2	5	6	2	6	14	6	399	0	Abutments.
4	5	0	3	0	3	0	180	0	Pilasters.
2	3	0	3	0	5	9	90	0	Backing to angle.
4	4	9	2	0	4	9	181	0	
4	4	9	2	0	4	6	171	0	Wing walls.
4	4	6	2	0	4	0	144	0	
4	4	6	2	0	3	6	126	0	
4	5	3	2	0	3	0	126	0	
							1417	0	$52\frac{13}{27}$ cubic yards.

Brickwork.

							Footings.		
2	0	3	1	3	15	6	9	8	Abutments.
2	0	3	1	3	13	0	8	2	Back ditto.
4	0	3	1	3	11	6	14	5	Pilasters and returns.
4	0	3	1	3	4	9			
4	0	3	1	3	4	6			Wing walls.
4	0	3	1	3	4	6			
4	0	3	1	3	9	6			
4	0	3	1	3	3	0			
2	4	6	10	0	14	6			Abutments.
2	2	6	5	6	14	6			Ditto.
2	5	0	1	4	14	6			Backing to arch.
2	4	6	1	4	14	6			
2	21	0	2	0	14	6			Ring arch.
2	0	2	1	0	18	10			String course.
4	1	8	5	0	21	6			Pilasters.
2	2	6	2	6	14	0			Back angles.
4	2	3	2	6	14	0			Back pilasters.
4	4	0	4	0	2	0			Spandril elevation.
4	6	0	2	0	2	0			
4	12	6	1	9	2	0			
4	5	0	3	4	3	6	233	4	Wing walls, worked.
4	9	6	3	0	3	3	370	6	Batter, $1\frac{1}{2}$ to 1 foot.
4	14	0	2	8	3	3			and pedestals
4	18	6	2	4	3	3			
4	23	0	2	0	4	0			
							—	—	cubic yards.

carried forward.

Brickwork, continued.

Brought forward, cubic yards.

No.	′	″	′	″	′	″	Cubic feet.	
4	1	0	1	4	46	0		String course.
4	0	4½	3	6	4	0		Under do., ends of bridge.
4	1	2	3	6	45	6	743 2	Parapet.
4	0	4½	3	6	3	6		Face of pilasters on parapet.
4	0	4½	3	6	5	0		
								cubic yards.

Face Pointing.

2	21	0	14	6	Superfic.			Soffit arch.
2	7	6	14	6				Abutments.
2	1	4	18	10				String course.
4	21	0	2	0				Face of ring of arch.
4	7	0	2	0				Do. abutments.
4	3	0	17	0				Spandril elevation.
8	3	6	46	6			1302 0	Parapets.
4	3	6	1	6				Return to ditto.
4	1	6	46	0				String course.
4	3	6	5	8				Face pilasters and pedestals.
4	3	6	3	0				
								superficial yards.

Pointing Batter, 1½ to 1 foot.

4	5	0	16	0			Face of pilasters.
4	1	8	16	0			Sides of ditto.
							superficial yards.

Batter and Curved.

4	7	6	16	0			Wing walls.
4	7	6	5	0			
2	2	0	2	6			
							superficial yards.

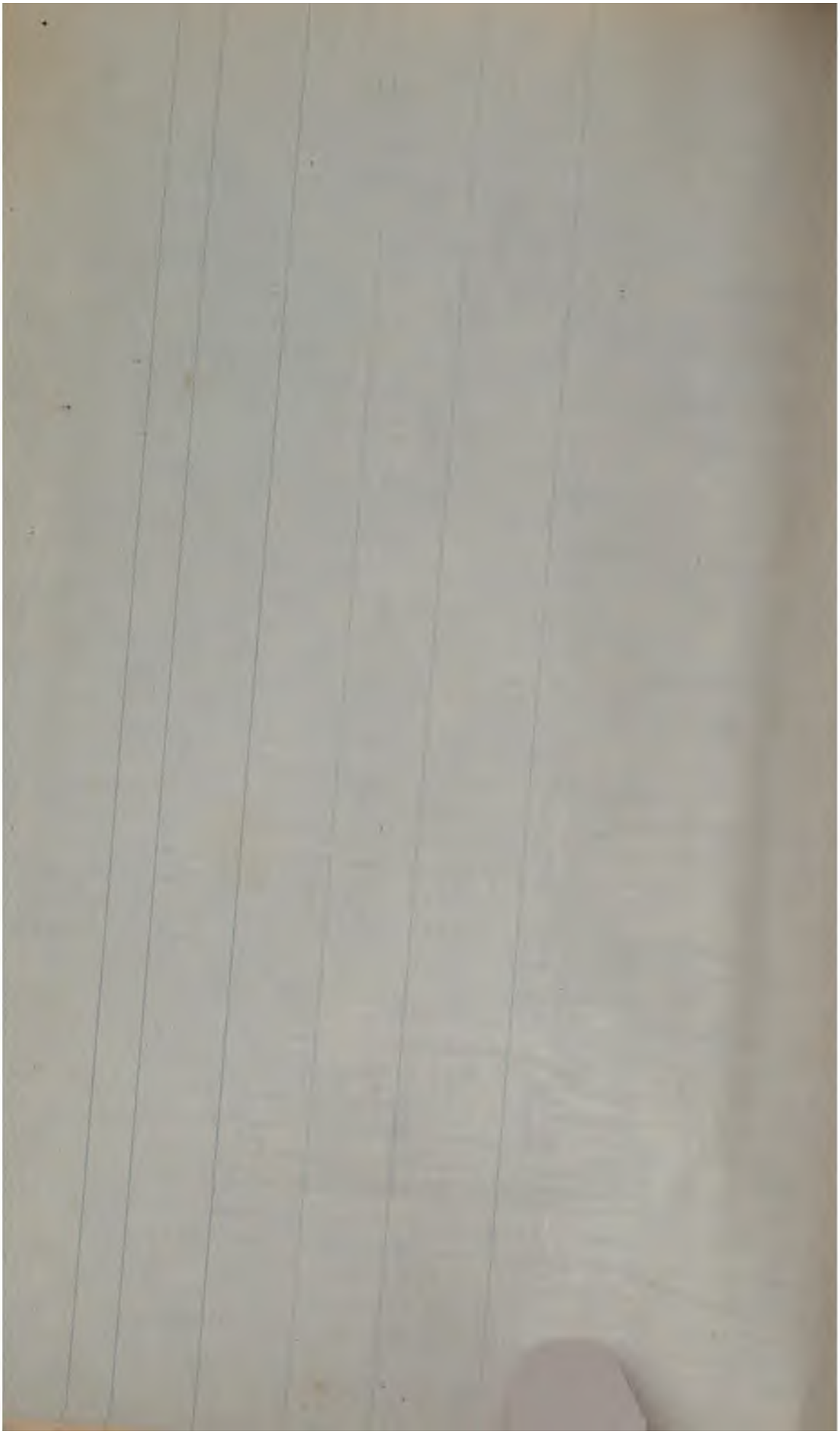
Extra.

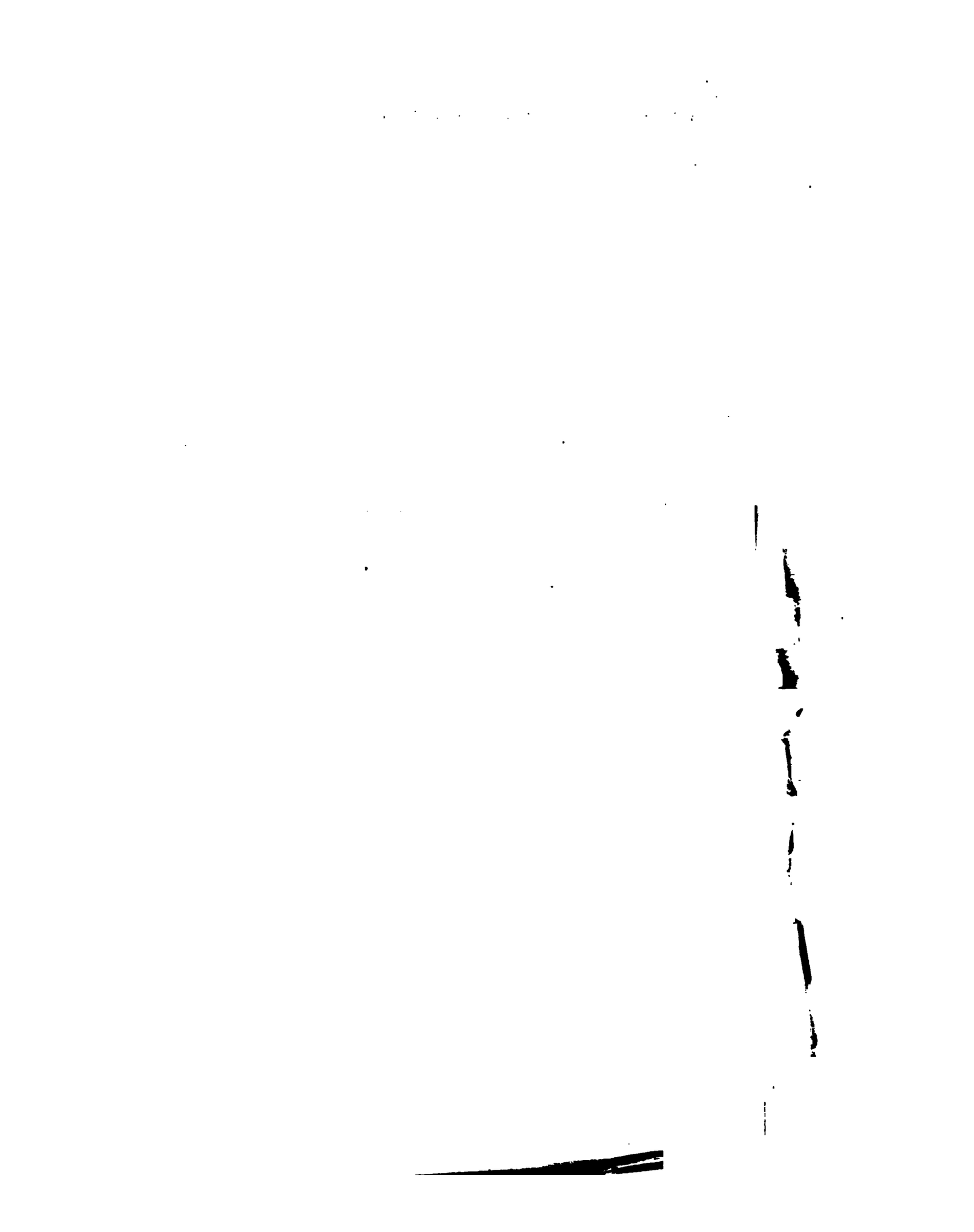
8	16	0	Run angle batter, cutting angles of pilasters.
			lineal yards.

Ashlar Stone.

4	0	6	1	4	16	0	42 8	Coping.
4	0	6	1	4	18	0		Ditto, curved.
4	0	9	1	8	5	4		Pilaster caps.
4	0	9	1	8	3	10		End ditto.
								cubic feet.

Provide for properly ramming and punning to back of arch, &c., &c.

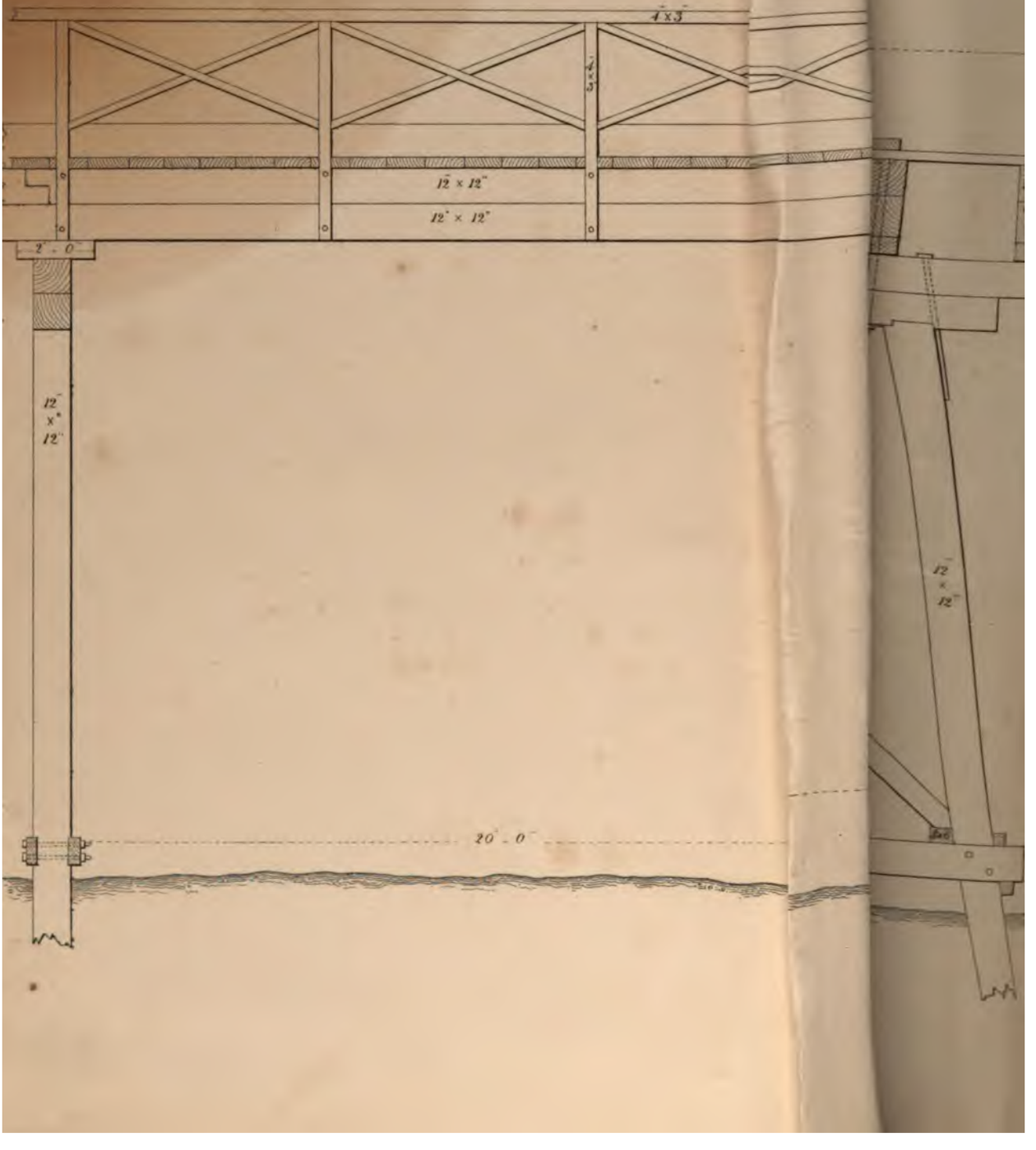


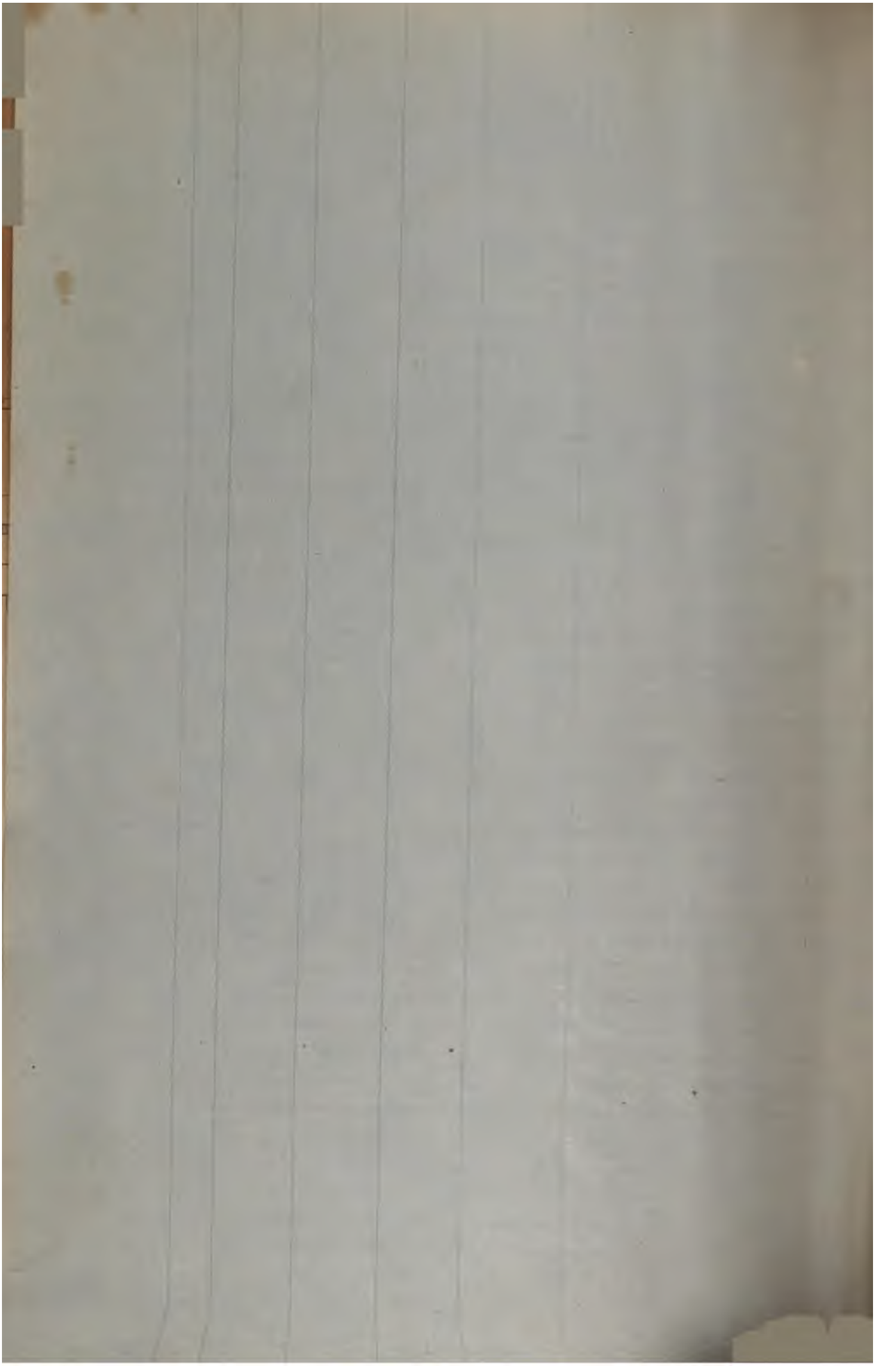


LONDON AND BRIGHTON RAILWAY.

BRICKLAYERS' ARMS BRANCH.

Nº7.





LONDON AND BRIGHTON RAILWAY

Bricklayers' Arms Branch.

Part of Timber Viaduct.

Drawing No. 7.

No.	′	″	′	″	′	″	Cubic feet.		
15	1	0	1	0	30	0	450	0	Piles.
									cubic feet.

Note.—The piles are taken at 14 feet below surface.

Rough Fir, part Framed.

10	0	6	1	0	27	0	135	0	Wailing pieces.
10	0	6	1	0	15	6	77	6	Braces.
5	1	0	1	0	22	0	110	0	Bottom transv. sleepers.
5	1	0	1	0	25	0			Top ditto.
20	0	6	1	0	2	0			Templates.
8	1	0	1	0	84	0			Longitudinal sleepers.
20	0	6	0	6	2	0			Outside templates.
4	0	6	1	0	84	0			Ditto sleepers.
4	0	4	0	8	84	0			Sleepers under rails.
									cubic feet.
84	0	4	1	0	26	6	2226	supl.	Planking.
							742	0	cubic feet.

Fir, Wrought and Framed.

2	0	3	0	9	84	0	31	6	Skirting.
2	0	3	0	4	84	0	14	0	Upper rail.
26	0	3	0	4	5	6			Uprights.
48	0	2	0	4	7	0			Braces.
									cubic feet.

Oak.

30	0	6	0	8	1	9			Blocks. cubic feet.

IRONWORK.

No.	′	″	′	″		lbs.	
20	2	0	0	1½	round bolts and screws,	240	
35	4	0	0	1½	ditto	840	
10	3	9	0	0¾	ditto	56	
10	2	6	0	0¾	ditto	38	
						1174	Cwt. lbs. 10 54 of iron.

NOTE.—See Table of Weights.

978 nine-inch ¾ spikes.
60 twelve-inch ditto.

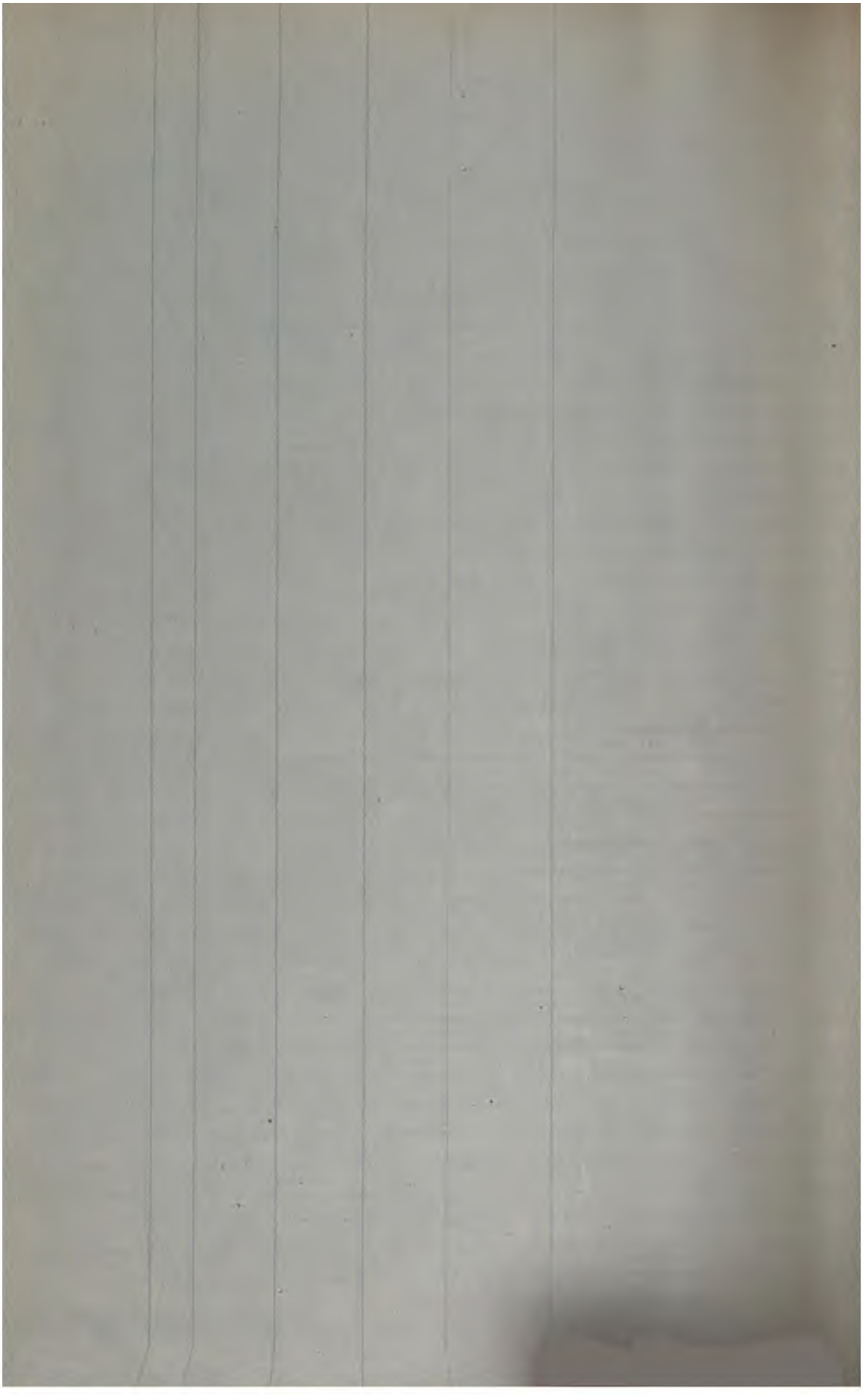
15 wrought iron pile-shoes, 15 lbs. each. 225 2 1

PAINTING, FOUR TIMES OIL.

2	1	9	84	0		294	0	Skirting.
2	1	2	84	0		196	0	Rails.
26	1	2	5	6				Uprights.
48	1	0	7	0				Braces.
								superficial yards.

15 Pile-shoes and rings fitting.

NOTE.—Allow for pile-driving and rings.



TIMBER WORK.

NOTE.—In admeasuring timber, care must be taken to allow for extra length for tenons, scarfing, ship-lapping, halving, &c.; and in piles, allowance for driving and depth of timber driven. Allow for fitting pile-shoes and rings. Take all iron straps and bands very accurately, and the bolts, nuts, and screws at the proper length. Look to the tables of weight of round and bar iron for all regular quantities of bolt and bar iron. For all other quantities, reduce them into cubic inches, and find the weight by the following rules:—

WROUGHT IRON.

Multiply the quantity of cubic inches by 28, cut off two figures to the right, the remainder is pounds.

CAST IRON.

Multiply the quantity of cubic inches by 27, cut off two figures to the right, the remainder is pounds.

NOTE to Drawing No. 8.—The skew bridge, angle 67°, is also built with an inclination of 1 in 25; and the wing walls being all at different curves and heights, will afford much instruction and information, if great attention be paid to its admeasurement.

SOUTHAMPTON AND WINCHESTER RAILWAY.

BRIDGE OVER RAILWAY FOR TURNPIKE ROAD FROM WINCHESTER TO SOUTHAMPTON.

DRAWING No. 8.

EARTH-WORK.

No.	′	″	′	″	′	″	Cubic feet.		
2	6	0	4	0	30	0	1440	0	Abutments.
4	6	0	4	6	6	0	648	0	Counterforts.
4	5	6	3	0	4	0	264	0	Pilasters.
2	4	6	2	0	4	0	72	0	Back ditto.
2	3	0	4	0	4	0	96	0	Ditto.
1	4	0	5	6	3	0			Wing walls at A.
1	5	0	3	9	3	0			
1	8	6	3	3	3	0			
1	15	0	3	3	3	0			
4	5	0	3	0	3	0			Pedestal. Pilasters.
2	4	6	4	0	3	0			Wing walls at B.
1	6	0	3	3	3	0			
1	3	0	3	0	3	0			
2	4	0	5	6	3	0			Wing walls, other end.
2	5	0	3	9	3	0			
2	8	6	3	3	3	0			
2	5	9	3	3	3	0			
									cubic yards.

Allow for punning, ramming, &c.—See Specification Clause.

BRICKWORK.

2	0	3	1	3	31	6	19	2	Footings. Abutments.
4	0	3	1	3	5	6	6	11	Angles.
4	0	3	1	3	6	6			Pilasters.
1	0	3	1	3	31	6			Wing wall A.
1	0	3	1	3	16	0			Ditto B.
2	0	3	1	3	23	9			Ditto, other end.
4	0	3	1	3	7	6			Pedestal. Pilasters.
2	4	6	10	0	30	6	2745	0	Abutments.
2	5	9	2	6	30	6	876	10	Ditto.
2	3	0	1	6	30	6			Backing to arch.
2	1	6	1	6	30	6			
2	0	6	3	6	30	6			
4	5	6	3	0	14	9			Counterforts.
2	0	4	1	0	35	2			String course.
2	2	0	18	0	30	6			Arch.
									cubic yards.

Carried forward.

POINTING, continued.

Brought forward, superficial yards.

No.	′	″	′	″	′	″	Superfic. feet.	
2	18	0	30	6				Arch soffit.
2	2	0	36	0				Ring of ditto.
4	1	9	18	0				Strings.
4	1	9	6	0				
4	1	9	3	9				
8	3	6	18	6				Parapet and pilasters.
8	3	6	5	0				
8	3	6	3	9				
4	1	6	3	6				Return of ditto.
12	0	4½	3	6				
4	4	3	5	0				Face of pilasters on parapet.
4	4	3	3	9				
2	2	5	21	6				Angle of ditto.
								superficial yards.

POINTING, CURVED ONLY.

1	1	9	36	0			63 0	Strings to wing walls.
1	1	9	18	0			31 6	
2	1	9	23	6				
2	3	6	36	0				Parapets.
2	3	6	18	0				
4	3	6	23	6				
								superficial yards.

POINTING, BATTER ONLY.

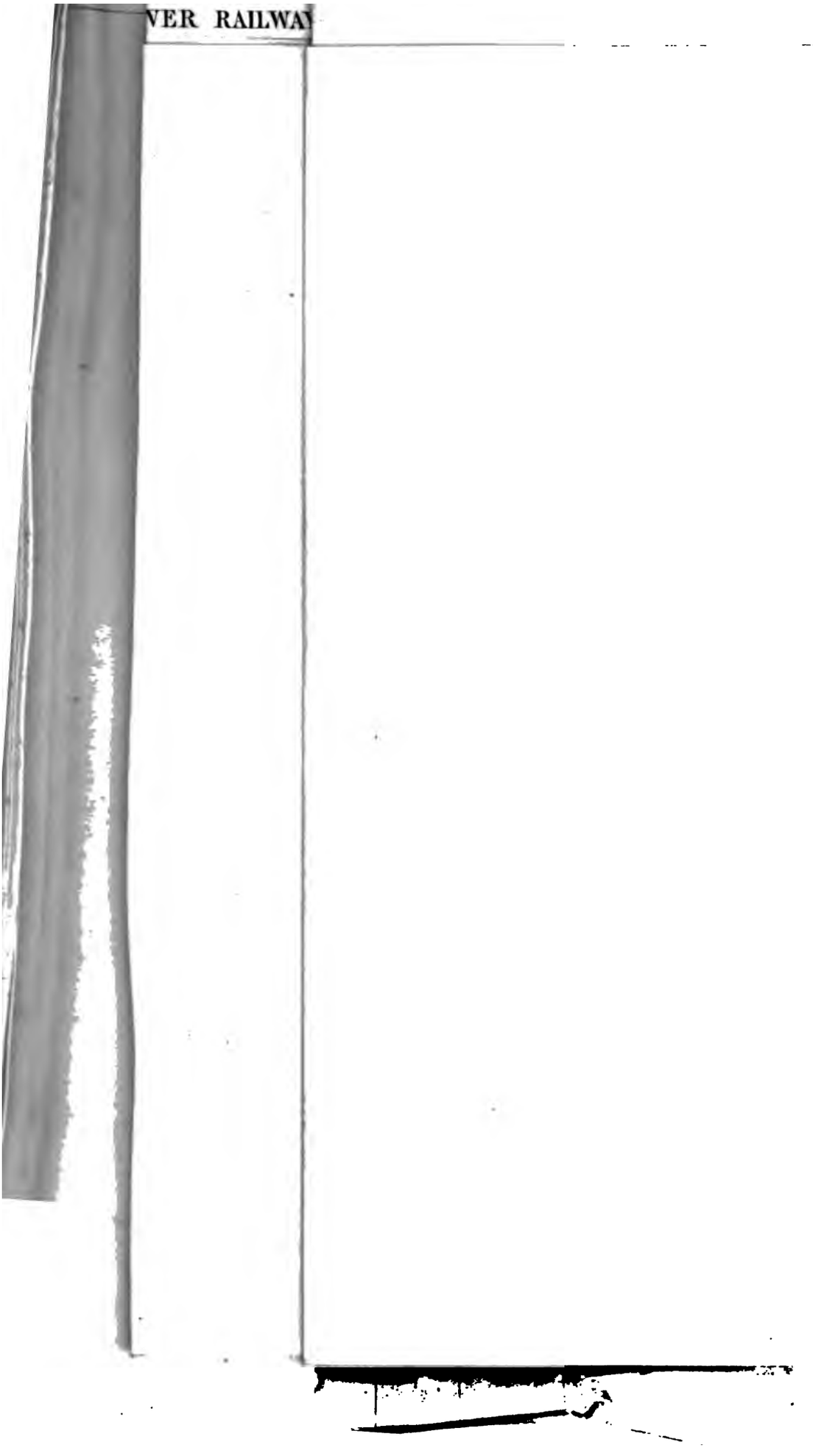
4	5	0	18	0				Face of pilasters.

POINTING, CURVED AND BATTER.

1	7	3	32	6			235 7	Wing walls.
1	10	6	14	6				
2	11	6	13	0				
2	25	6	3	9				
								superficial yards.
8	18	0	Extra angle cutting to pilasters.					

ASHLAR STONE.

							Cubic feet.	
4	0	6	1	4	18	4		Parapet.
4	0	9	1	10	3	9		Caps, pilaster.
4	0	9	1	10	5	3		
								cubic feet.



ELEVATION. BRICKWORK, continued.

Brought forward, cubic yards.

No.	′	″	′	″	′	″	Cubic feet.		
2	2	0	3	0	7	6	90	0	Right hand spandrils to arch.
2	2	0	1	6	12	0	72	0	
2	2	0	0	3	18	0			
2	2	0	2	0	6	0			
2	2	0	0	3	18	0	18	0	Left hand ditto.
2	2	0	2	6	5	6	55	0	
2	2	0	1	3	12	6			
									cubic yards.

BRICKWORK, BATTER ONLY.

2	1	9	4	3	15	0	223	1	Angle blocks behind the pilasters and end of abutments.
2	1	3	1	9	15	0			
2	2	8	2	0	15	0			
2	3	0	2	0	15	0			
2	1	4	5	0	22	6			Face pilasters.
2	1	4	5	0	20	6			
									cubic yards.

BRICKWORK CURVED AND BATTER.

1	5	6	3	5	3	8	68	11	Wing wall A.
1	11	0	3	0	3	3	107	3	
1	19	6	2	8	2	9			
1	34	6	2	4	3	6			
1	36	0	2	0	2	11			
1	4	6	3	0	3	3			Wing wall B.
1	9	0	2	8	3	0			
1	15	0	2	4	3	6			
1	18	0	2	0	3	0			
2	4	6	3	9	3	8			Wing walls, the other end of bridge.
2	9	0	3	5	3	3			
2	14	0	3	0	3	0			
2	18	6	2	8	3	6			
2	23	0	2	4	2	9			
2	23	6	2	0	3	9			
									cubic yards.

Brickwork, Curved only Two Faces.

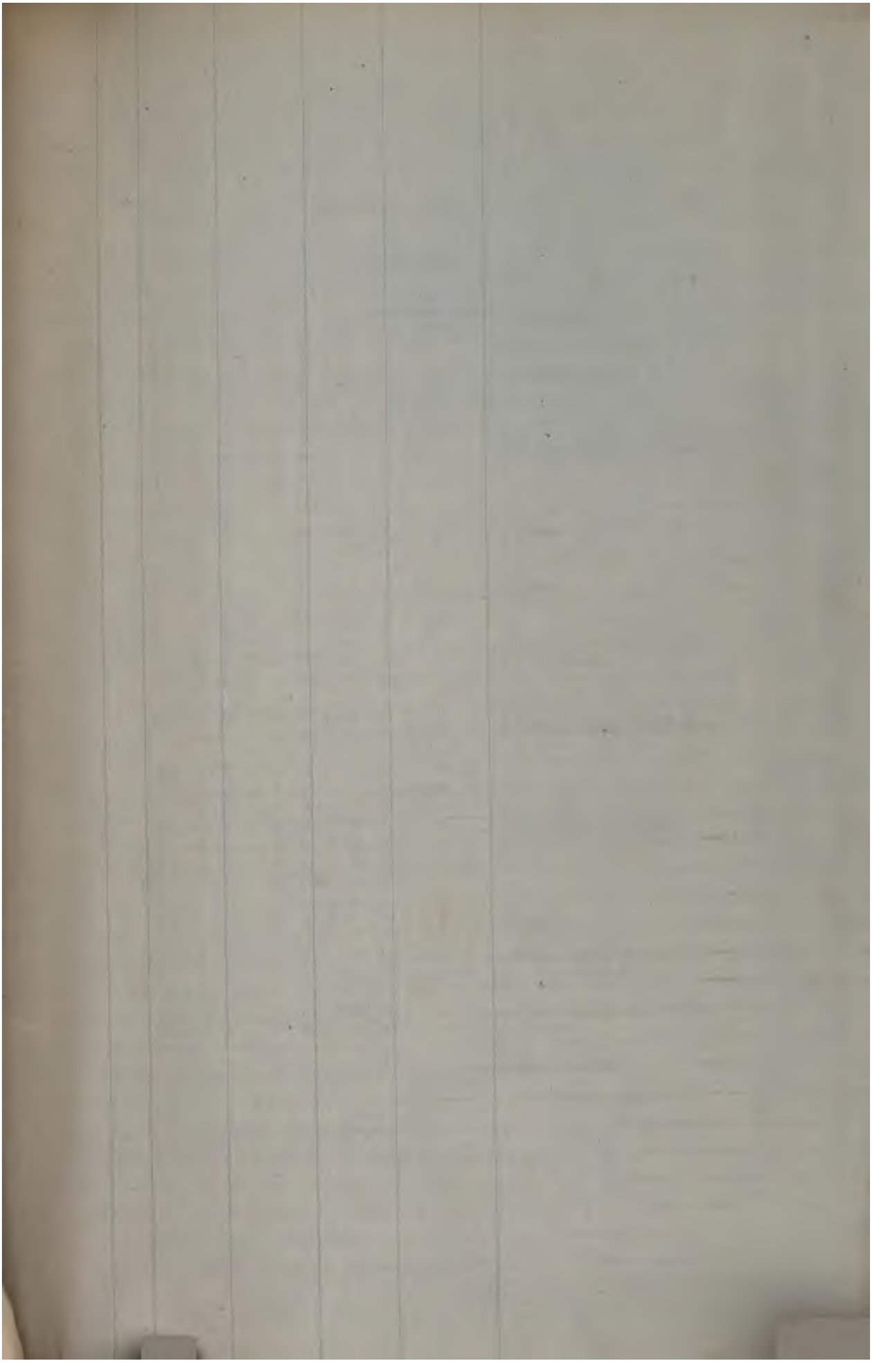
No.	′	″	′	″	′	″	Cubic feet.	
1	0	9	1	6	36	0	40 6	
1	0	9	1	6	18	0	20 3	String course.
2	0	9	1	6	23	6		
1	1	2	3	6	36	0		
1	1	2	3	6	18	0		Parapet.
2	1	2	3	6	23	6		
								cubic yards.

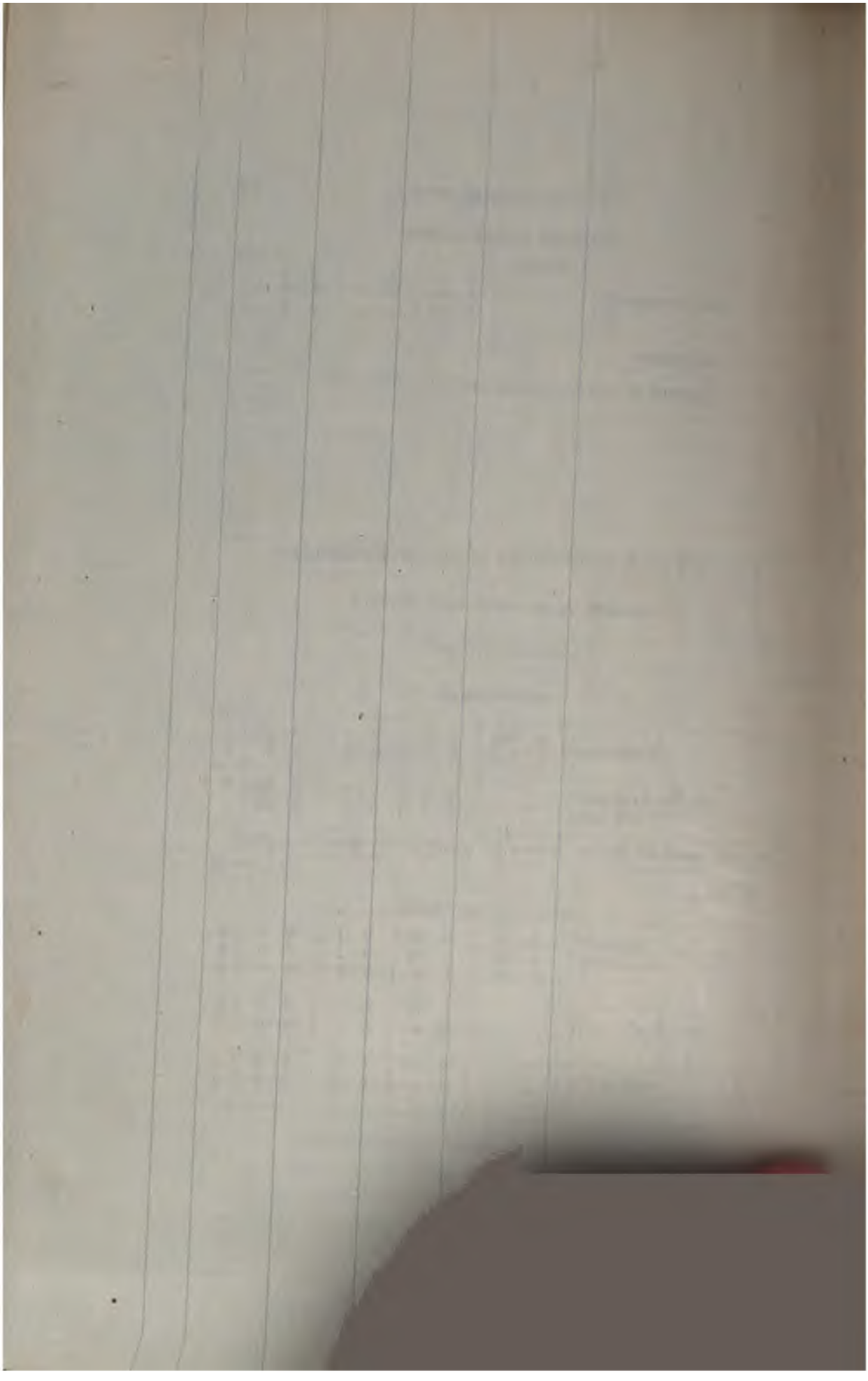
Brickwork, Two Face Plain.

4	0	9	1	6	18	0		
4	0	9	1	6	6	0	27 0	Strings.
4	0	9	1	6	3	9		
4	1	2	3	6	18	6		
4	1	2	3	6	5	0		Parapet and pilasters.
4	1	2	3	6	3	9		
4	0	4½	3	6	5	0		Face pilaster.
4	0	4½	3	6	3	9		Pedestal, &c.
								cubic yards.

Pointing.

					Superfic. feet.		
2	10	0	30	6	610	0	Abutments.
4	2	0	10	0	80	0	Ditto.
2	1	8	35	2	117	3	String.
2	3	0	7	6			
2	1	6	12	0			
2	0	3	18	0			Large right-hand spandrils to arch.
2	2	0	6	0			
2	1	9	6	0			
2	1	9	5	0			
2	0	3	18	0			
2	2	3	5	6			
2	1	3	2	6			Left hand ditto.
2	1	9	6	0			
2	1	9	5	0			
							superficial yards.
							Carried forward.





Pointing.

No.	′	″	′	″	′	″	Cubic feet.		
4	3	6	1	6			21	0	} Parapets.
8	3	0	77	6			1860	0	
4	1	2	77	6					} String course, upper order, and projection only.
6	0	6	11	9					} Spandrils, elevation, including bottom order of string course.
16	1	9	17	0					
32	1	0	6	3					
16	4	6	3	0					
16	2	0	2	0					
16	1	3	2	0					
16	1	0	1	0					
16	2	0	21	6					Rings, face of arches.
6	11	4	4	6					} Front of piers.
6	2	0	4	10					
4	8	0	3	0					Pilasters.
6	13	4	27	6					Piers.
8	21	6	27	6					Soffit of arches.
									superfic. yards.

Ashlar Stone.

4	0	8	1	4	76	7	272	8	Coping.
4	1	0	1	6	8	4			Caps.
									cubic feet.

Iron.

3	0	6	Iron pipes, with heads 7 feet long.

Puddling.

8	1	0	23	0	21	6	3956	0	$146\frac{14}{27}$ cubic yards.

Deduct from Brickwork.

4	10	0	5	0	6	0	1200	0	} From piers and abutments.
3	11	0	7	0	4	6	1039	6	
							2239	6	$82\frac{25}{27}$ cubic yards.

TIMBER VIADUCT, TAMWORTH SALT

TIMBER VIADUCT, TAMWORTH SALT.

Drawing No. 10.

Earth-Work.

No.	′	″	′	″	′	″	Cubic feet.	
1	6	0	4	0	25	0		
1	4	9	4	0	25	0		
								cubic yards.

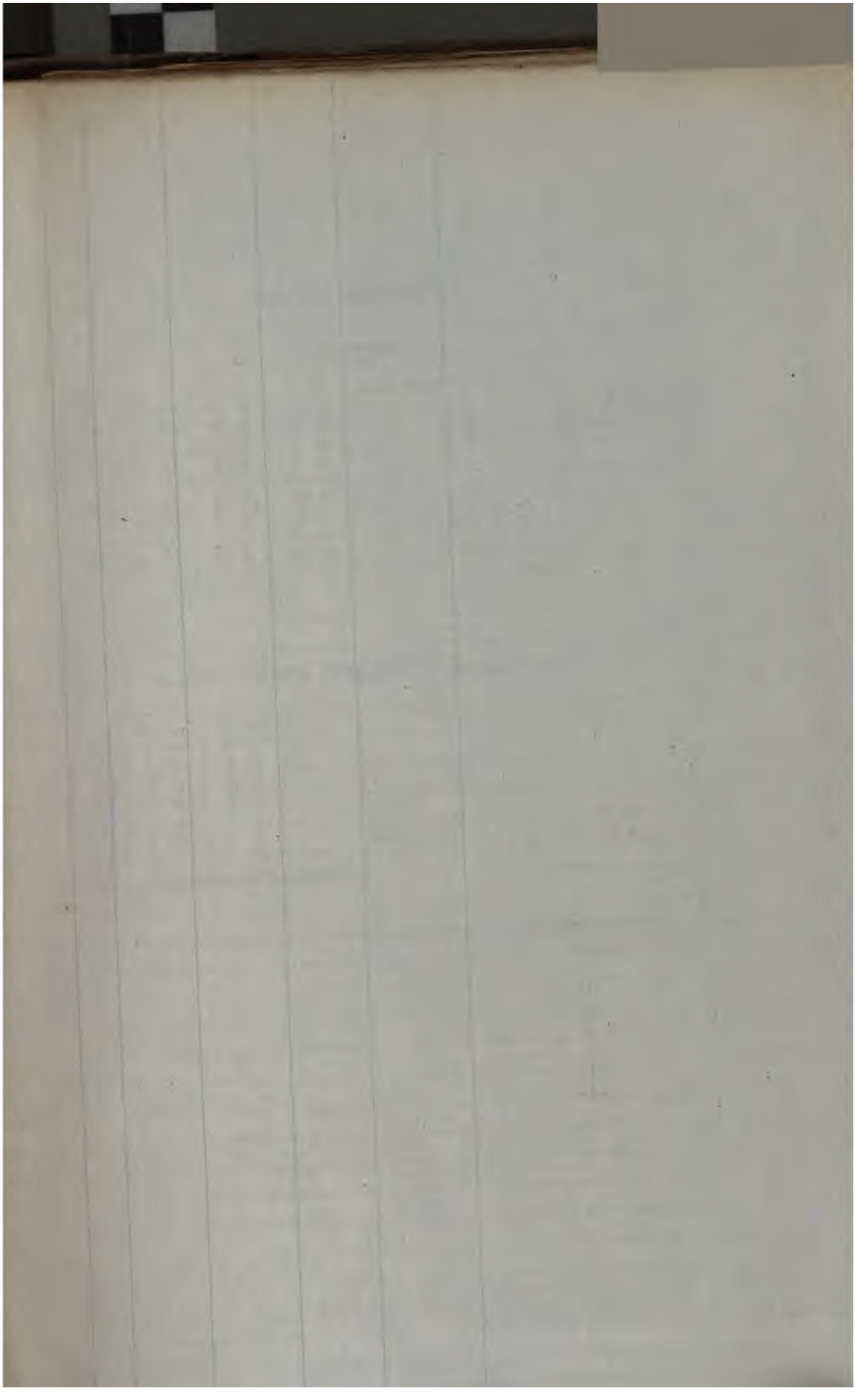
Brickwork.

2	0	6	0	9	26	6		} Footings.
4	0	6	0	9	3	0		
2	2	9	6	0	25	0		Abutments.
								cubic yards.
							Superfic. feet.	
2	5	0	25	0				} Face pointing.
4	1	6	2	0				
								superfic. yards.

Timber.

48	1	0	1	0	28	0	1344	0	} Piles.
12	1	0	1	0	25	0	300	0	
12	1	0	1	0	25	0	300	0	Beams.
12	1	0	1	0	27	0	324	0	Main braces.
24	0	9	0	6	10	0			Upright ditto.
16	0	6	0	9	9	0			Transverse ditto.
12	1	0	0	10	9	0			Ditto to truss.
2	1	0	1	0	25	0			Transverse beam to ditto.
24	1	0	0	8	8	6			Braces to bays.
12	1	0	0	8	10	0			Heads to ditto.
24	1	0	1	0	3	0			Abutting pieces.
24	1	0	0	6	6	0			Templates.
12	1	0	0	6	11	6			Ditto.
24	1	0	1	0	57	6			Horizontal sleepers.
8	0	6	0	8	57	6			Sleepers for rails.
2	0	4	26	0	57	6			Planking.
									cubic feet.

TIMBER VIADUCT, TAMWORTH SALT



Ironwork.

No.	′	″	′	″	′	″	Cubic inches.	
21	0	0½	0	3	8	0		} Iron straps to truss.
3	0	0½	0	3	6	6		
12	0	0½	0	3	4	6		
6	0	0½	0	3	3	4		
36	0	0½	0	1½	2	8		} Posts.
4	0	0½	0	2	4	0		
12	0	0½	0	2	6	0		Collar beam.
							Cwt. lbs.	

Round Bolts, Nuts, Plates, and Screws.

						lbs.
2	25	0	0	2½		
30	4	0	0	1		
84	2	9	0	1		
24	2	2	0	1		
48	2	3	0	1		
48	1	9	0	1		
6	1	10	0	1		
60	Pile shoes, 15 lbs. each.					

TIMBER VIADUCT,

To be carried to any Length, with Iron Tension Rods.

One Span only and Two Piers.

Drawing No. 11.

Earth-Work.

No.	′	″	′	″	′	″	Cubic feet.		
2	29	0	9	0	8	0	4176	0	191$\frac{12}{27}$ cubic yards.

Brickwork.

4	29	0	0	9	2	6	217	6	} Footings.
4	6	0	0	9	2	6	45	0	
2	10	0	25	0	6	0	3000	0	} Piers, measured solid.
2	16	0	25	0	4	8	3733	4	
							6995	10	259$\frac{5}{27}$ cubic yards.

Pointing.

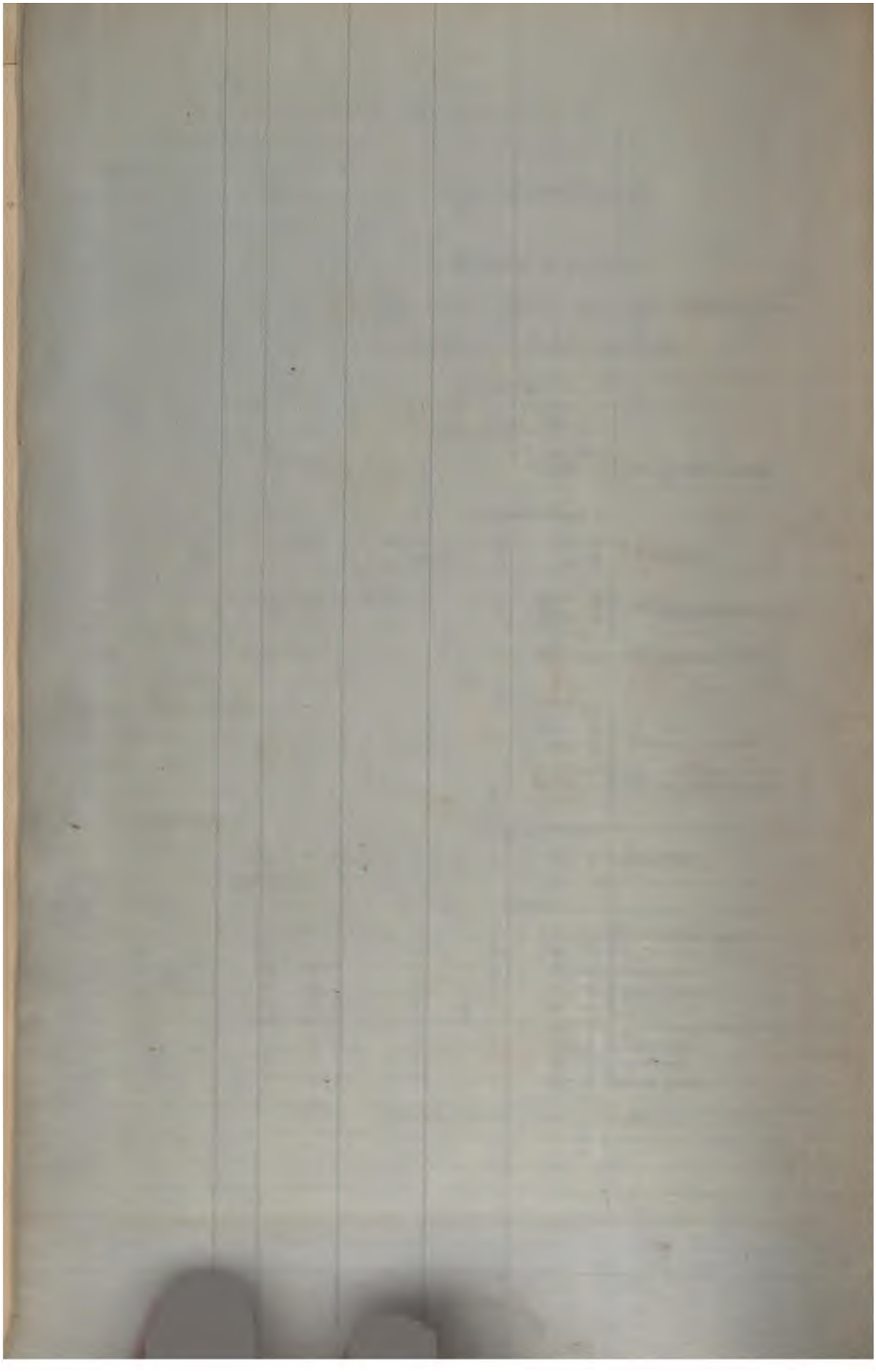
4	16	0	25	0			1600	0	
4	16	0	4	8			298	0	
							1898	0	211 superficial yards.

Ashlar Stone.

2	5	0	3	6	1	0	35	0	cubic feet.

Timber.

12	65	0	1	0	1	0	780	0	Main beams and ties.
4	36	0	1	0	1	0	144	0	Upper truss-head.
4	12	6	1	0	1	0	50	0	Lower ditto.
8	13	0	1	0	1	0	104	0	Upper braces.
8	25	0	1	0	1	0	200	0	Lower ditto.
16	2	6	1	0	1	0	40	0	Upper templates.
8	4	0	1	0	1	0	32	0	Lower ditto.
8	2	6	1	0	1	0	20	0	Puncheons.
8	4	9	1	0	1	0	38	0	Queen posts.
			Carried forward				1408	0	cubic feet.



TIMBER, continued.

No.	′	″	′	″	′	″	Cubic feet.		
							1408	0	Brought forward.
8	10	0	1	0	1	0	80	0	Braces, transverse.
16	8	0	1	0	1	0	128	0	Ditto.
4	18	6	1	0	1	0	74	0	Bed frame.
8	3	6	1	0	1	0	28	0	Ditto.
4	65	0	0	8	0	4	57	10	Sleepers for rails.
							1775	10	cubic feet.
81	25	0	0	11	0	3	2025 lin.		Plank, foot run.

WROUGHT FIR.

2	65	0	1	0	0	4	43	4	Skirting.
2	65	0	0	4	0	4	14	6	Top rail.
18	5	0	0	4	0	4	10	0	Posts.
16	2	6	0	4	0	2	2	2	Muntens.
16	8	0	0	4	0	3	10	8	Braces, twice.
							80	6	cubic feet.

IRONWORK.

							Cubic inches.		
16	28	0	0	4	0	1½	2688	0	Suspension rods, circular ends.
8	12	0	0	4	0	1½	576	0	Ditto.
16	1	6	0	5	0	0½	60	0	Plates for pins.
							3324	0	930 lbs. = 8 cwt. 34 lbs.

8 pairs expansion springs and plates.

							lbs.		
16	1	6	0	3			576	0	Round bar pins.
4	16	6	0	3			1584	0	Bolts and screws.
8	4	0	0	1¼			136	0	Ditto.
24	3	2	0	1¼			323	0	Ditto.
2	8	4	0	2			184	8	Ditto.
4	6	6	0	2			286	0	Ditto.
							3089	8	lbs. = 1 ton 7 cwt. 65 lbs.

One Tunnel and Hold-down Block Frame.

Brickwork.

No.	′	″	′	″	′	″	Cubic feet.		
1	1	0	1	6	50	0	75	0	Front footing.
1	2	6	2	6	26	0	162	6	Backing.
2	0	9	4	0	46	0	276	0	Sides of tunnel.
1	0	9	6	0	44	0	198	0	Arch.
1	1	2	4	6	50	0	262	6	Invert.
1	1	2	4	0	6	6	30	4	End.
							1004	4	$37\frac{5}{27}$ cubic yards.

32 feet cube scabled granite bed, 32 0 cubic feet.

Iron.

							Cubic inches.		
8	104	0	0	4	0	$1\frac{1}{2}$	4992	0	Sustaining tension rods.
8	4	0	0	4	0	$1\frac{1}{2}$	288	0	Block ends to rods.
4	2	0	0	6	0	4	2304	0	Block pins.
							7584	0	lbs. 2123
									192

Ton cwt. lbs. 1 0 75

12 Iron pile shoes, 16 lbs. each . . 192

52 nine-inch $\frac{3}{4}$ spikes.

Timber.

							Cubic feet.		
6	16	0	1	0	1	0	96	0	Back piles driven.
6	10	0	1	0	1	0	60	0	Upright ditto.
6	12	0	1	0	1	0	72	0	Braces framed and pinned.
4	20	0	1	0	0	3	20	0	Plank.
1	6	0	1	0	0	3	1	6	Ditto.
							249	6	249 6 cubic feet.

SUMMARY.

Timber Viaduct, 60 Feet Span. Drawing No. 11.

One Span and Two Piers.

							£	s.	d.
191	19	Cub. yds.	Earth-Work removed .	0	1	3	12	2	0
259	2	Ditto.	Brickwork	1	4	9	320	0	0
1775	10	Cub. feet.	Fir, rough and part framed .	0	3	9	332	19	6
2025	0	Lin. feet.	Fir, 3-inch plank and spikes	0	1	0	105	5	0
80	6	Cub. feet.	Fir, wrought and framed .	0	4	6	16	2	0
8	34	Cwt.	Best bar iron	0	0	6	23	5	0
1 7	65	Tons	Best bolt iron nuts and screws	0	0	4½	56	6	10
	8	No.	Pairs of expansion springs and plates . . .	3	10	0	28	0	0
211	0	Sup. yds.	Face pointing, omitted .	0	1	6	15	16	0
			Total for one span and two piers				909	16	4

Summary for One Tunnel and Pier.

37	5	Cub. yds.	Brickwork	1	4	9	43	19	0
1 0	.75	Tons	Best bar iron, fitted .	0	0	6	57	17	6
249	6	Cub. feet.	Fir	0	3	0	37	8	6
126	0	Lin. feet.	Pile driving . . .	0	1	0	6	6	0
							145	11	0
									2
							291	2	0
			Quantity in two tunnels, &c , added to the quantity of span				1200	18	4

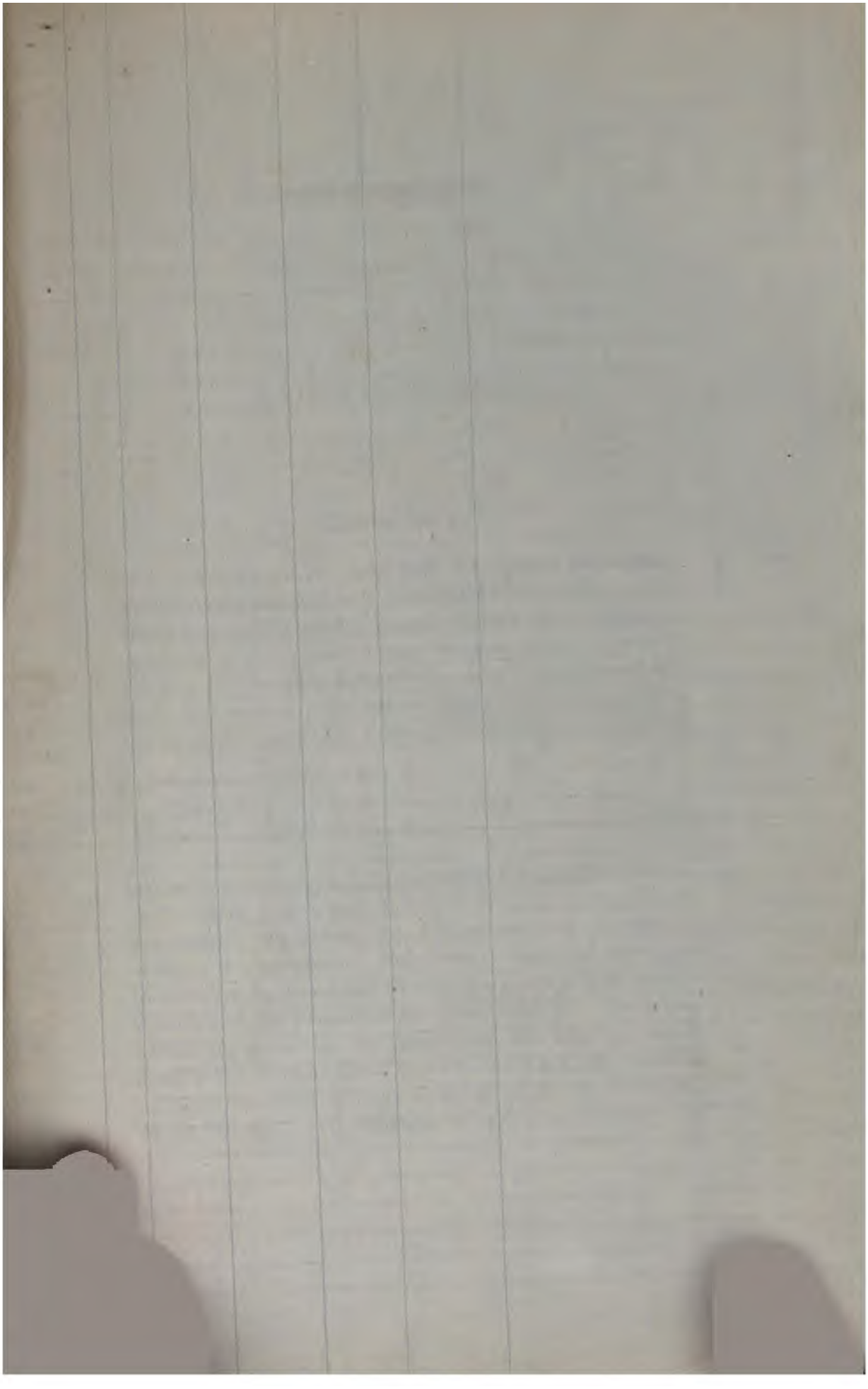
Now this is the quantity for one span and the double tunnels, &c., &c.; but suppose the viaduct extended to six spans, or 360 feet,—

Deduct from this one pier brickwork .	160	0	0
Ditto pointing	7	18	0
Ditto earth-work	6	1	0
Ditto fir, 217 cubic feet	40	13	9
	£214	12	9

Carried forward,

	£	s.	d.
Brought forward,			
Amount of one span and two piers . . .	909	16	4
Deduct from ditto	214	12	9
	695	3	7
The viaduct to continue six times . . .			6
	4171	1	6
Add two tunnels, &c.	291	2	0
Add the deductions	214	12	9
	£4677	0	3

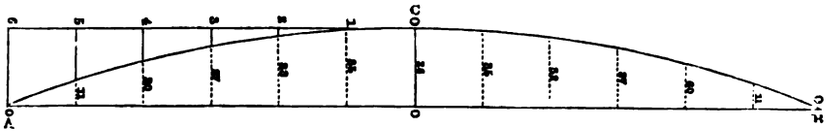
NOTE. — Allowance must be made for any contingencies likely to occur in the formation of the work.



RAILWAY CURVES.

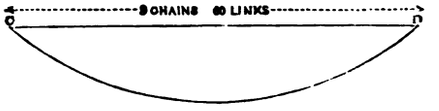
DRAWING No. 12.

IT is a well-known principle, that if a tangent be drawn to a circle of the extent usually employed for railway curves, the offsets from such tangent increase in distance from such curve according to the square of their distances from the point of contact; therefore, the distance of a curve from the chord of a circle, will be at all points less the distance of the tangent from the curve, if equal chain distances be set off from the point of

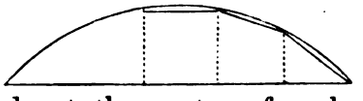


contact 0, at 1, 2, 3, 4, 5, 6, the offsets from the tangent c c, to the curve 1, 2, 3, 4, 5, 6, will be 1, 4, 9, 16, 25, 36, respectively, or the square of their distance from the point of contact; if we retrace our steps from A along the chord A B, to its centre, 0, the central offset of the chord will be equal to the offset of the tangent at six chains, and the other offsets will be the same, ess the offsets from the tangent; then to describe the curve by offsets from the chord A B, the distances will be respectively at every chain 0, 11, 20, 27, 32, 35, 36, 35, 32, 27, 20, 1 , 0; therefore, in setting out the line A B,

(Drawing No. 12, Fig. 1,) upon inspecting the plan, the centre line of which is straight to C, a curve will be required with a radius of 20 chains from C to D. By measurement from the nearest prominent land-marks on plan, poles should be erected on the centre line at C and D, and if necessary several, that is, a ranging line must be formed to measure the chord C D straight. When that line is measured, whatsoever be its length, draw the same to scale on paper, as the dotted line

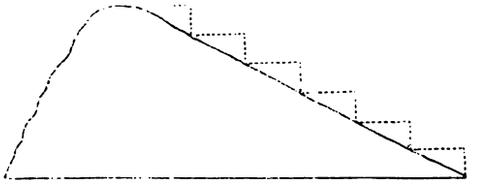


C D; then open the compasses to the same scale to 20 chains, place one point at C, and describe the arch *a a*, then do the same at D and intersect them; then, by placing the point at the intersection, you describe the curve C D, measure the offsets at every chain as before described, and the curve can be set off with great ease, care being taken that the offset line be set off at right angles from the chord, which can be very readily done by the theodolite; or, otherwise, proceed as before from D to E, and again in the other side of the line from E to B, and the figures will be found to range as figured in the plan. Should the curve be of small radius, an intermediate chord may be measured at every chain, thus—



and a set-off made at the centre of each. Care must be taken in measuring the chord, if over high ground for a cut-

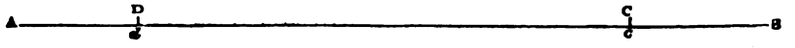
ing, to range the lines perfectly straight, and to measure horizontally by lifting the chain thus,—



if very steep measure by half chains only. There are very many able methods published for setting out railway curves, among which Heald's system comprises simplicity and accuracy.

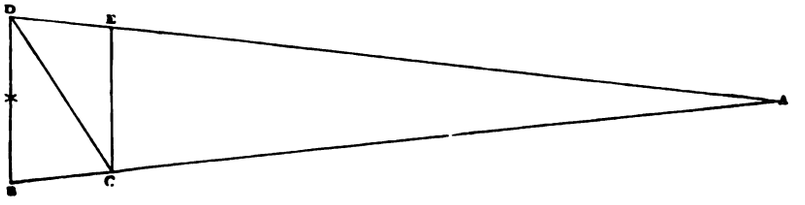
RANGING LINES.

In ranging lines over high ground, where two marks cannot be seen from one spot, observe the following directions:—suppose *a* and *b* are two stations, between which the poles are to be ranged in a straight line, but at no part of it can *a* and *b* be both seen; let one assistant place himself where he can see the mark at *a*, at as great a distance as he can from it, as *q* C, let another assistant place himself somewhere between C and *a*, so as to have a sight of *b*, as at D; C and D must move themselves till D ranges with *a* at C, and C ranges with B at D, which will be at *c d*, where poles must be put up and the lines measured.



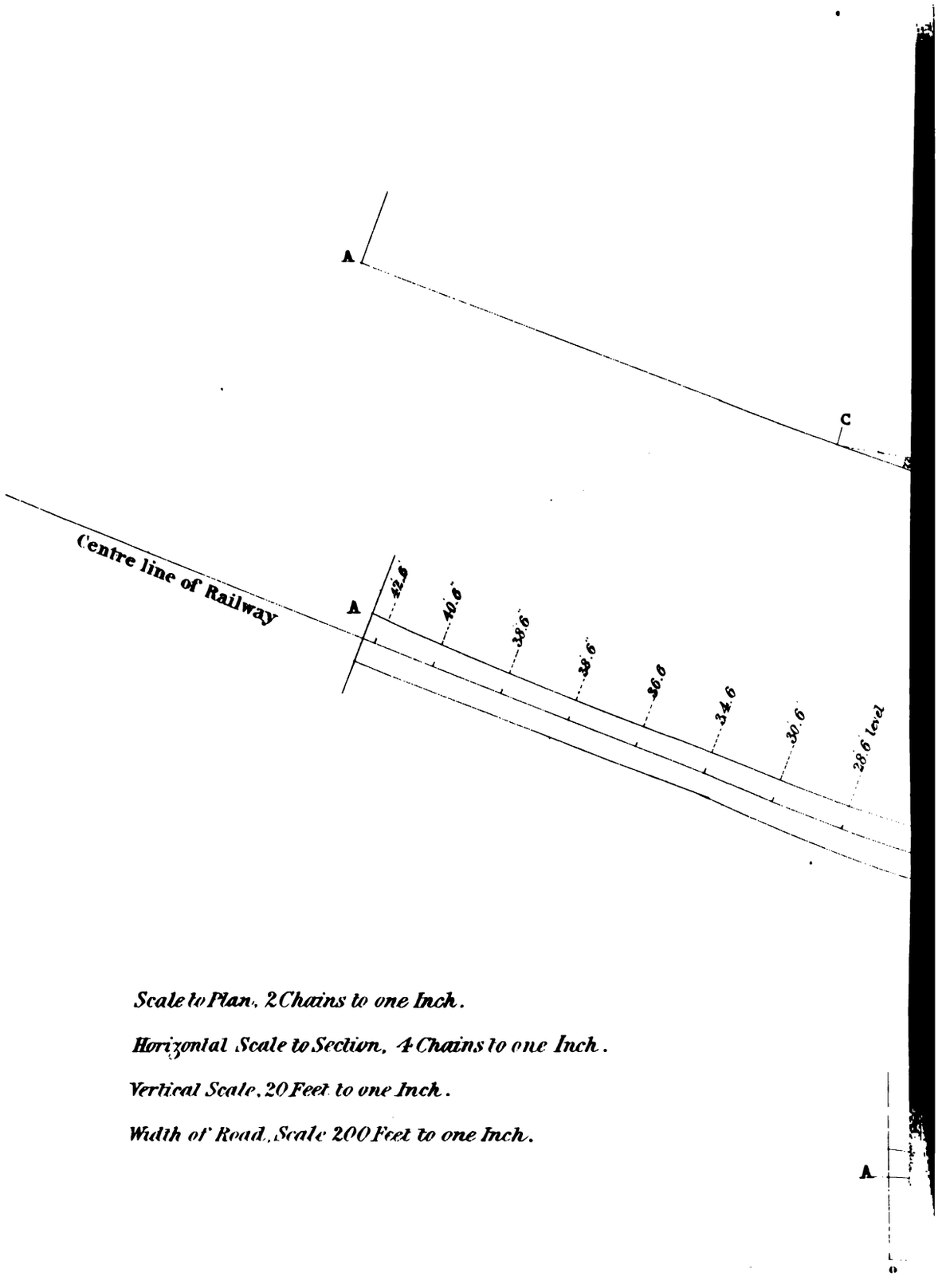
To find the distance of an inaccessible object by the chain, observe the following directions. Let A be the object, and the place of observation B; let an assistant go forward to C, and place a pole in a direct line with the object A; let B change his situation to D, and let C place a pole in a line between D and A, as at E. Measure the four sides of the trapezium B C D E, and a diagonal C D, which must be accurately mea-

sured and plotted. Produce the lines B C and D E till they intersect, which will be the proper situation for A; and the distance from X to A may be measured on the scale it was plotted from.



UNSOILING,

Or the width of ground required for extent or top of cuttings and footings of embankments. In Drawing No. 12, Fig. 2, is the plan of part of a railway, 32 chains in length, and Fig. 3 is a section of it. Now to set out this ground we begin at A (Fig. 2), the surface level of the road is 33 feet, and by reference to the section at A, the cutting or vertical height will be found to be 7 feet; slopes 2 to 1 will give 14 feet on each side, equal to 28 feet, to which add 33 feet, the surface level, making together 61 feet, one-half of which, viz., 30 feet 6 inches, and 12 feet for outside banks and ditches, making 42 feet 6 inches, set off on each side of the centre of the line, gives the width at that spot; the vertical height at the first chain is 6 feet, and the dimensions follow, thus—

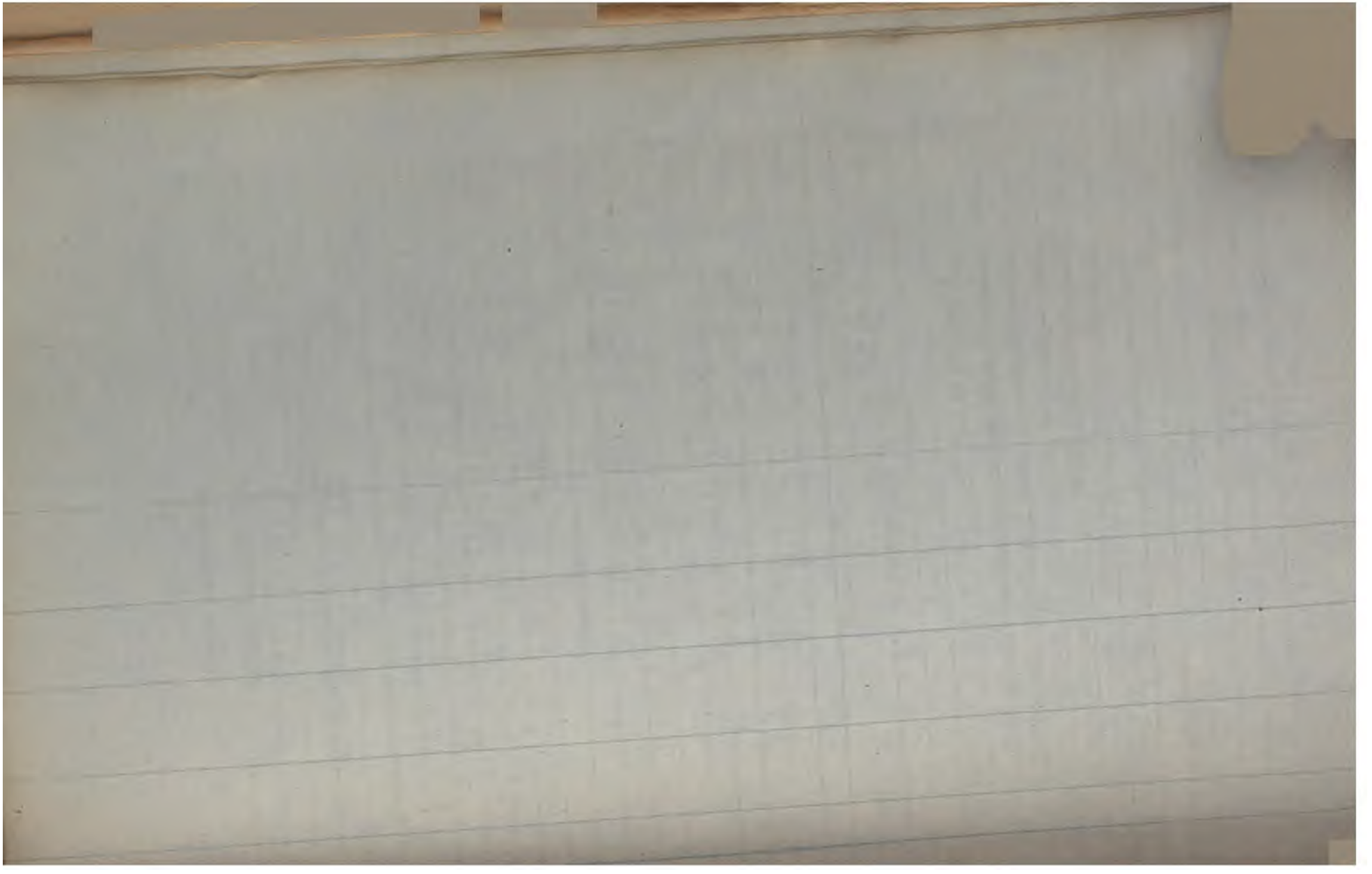


Scale to Plan, 2 Chains to one Inch.

Horizontal Scale to Section, 4 Chains to one Inch.

Vertical Scale, 20 Feet to one Inch.

Width of Road, Scale 200 Feet to one Inch.



Ce

BEGIN CUTTING No. 1, A.

Chains.	Vertical height.		Slopes 2 to 1. Right hand.		Slopes 2 to 1. Left hand.		Surface level.		Total whole width added, without ditches.		Set off each side of centre line.		Total half, including outside banks and ditches, 12 feet each side.	
No.	′	″	′	″	′	″	′	″	′	″	′	″	′	″
0	7	0	14	0	14	0	33	0	61	0	30	6	42	6
1	6	0	12	0	12	0	33	0	57	0	28	6	40	6
2	5	0	10	0	10	0	33	0	53	0	26	6	38	6
3	5	0	10	0	10	0	33	0	53	0	26	6	38	6
4	4	0	8	0	8	0	33	0	49	0	24	6	36	6
5	3	0	6	0	6	0	33	0	45	0	22	6	34	6
6	1	0	2	0	2	0	33	0	37	0	18	6	30	6
7	level		0	0	0	0	33	0	33	0	16	6	28	6

Add 12 feet ditches.

EMBANKMENT No. 1.

10	5	6	11	0	11	0	33	0	55	0	27	6	39	6
11	5	6	11	0	11	0	33	0	55	0	27	6	39	6
13	level		0	0	0	0	33	0	33	0	16	6	28	6

CUTTING No. 2.

16	7	0	14	0	14	0	33	0	61	0	30	6	42	6
17	10	0	20	0	20	0	33	0	73	0	36	6	48	6
19	12	0	24	0	24	0	33	0	81	0	40	6	52	6
21	11	0	22	0	22	0	33	0	77	0	38	6	50	6
23	7	0	14	0	14	0	33	0	61	0	30	6	42	6
25	level		0	0	0	0	33	0	33	0	16	6	28	6

EMBANKMENT No. 2.

26	2	0	4	0	4	0	33	0	41	0	20	6	32	6
27	level		0	0	0	0	33	0	33	0	16	6	28	6

CUTTING No. 3.

32	18	0	36	0	36	0	33	0	105	0	52	6	64	6

When the ground slopes regularly, as from 27 to 32 chains, it is not necessary to set off every chain. Now set off the distances on each side of the centre line, as marked in plan, drive in stakes at each, and a line drawn from stake to stake incloses the width of ground required for the formation of banks and cuttings.

[illegible]

[illegible]

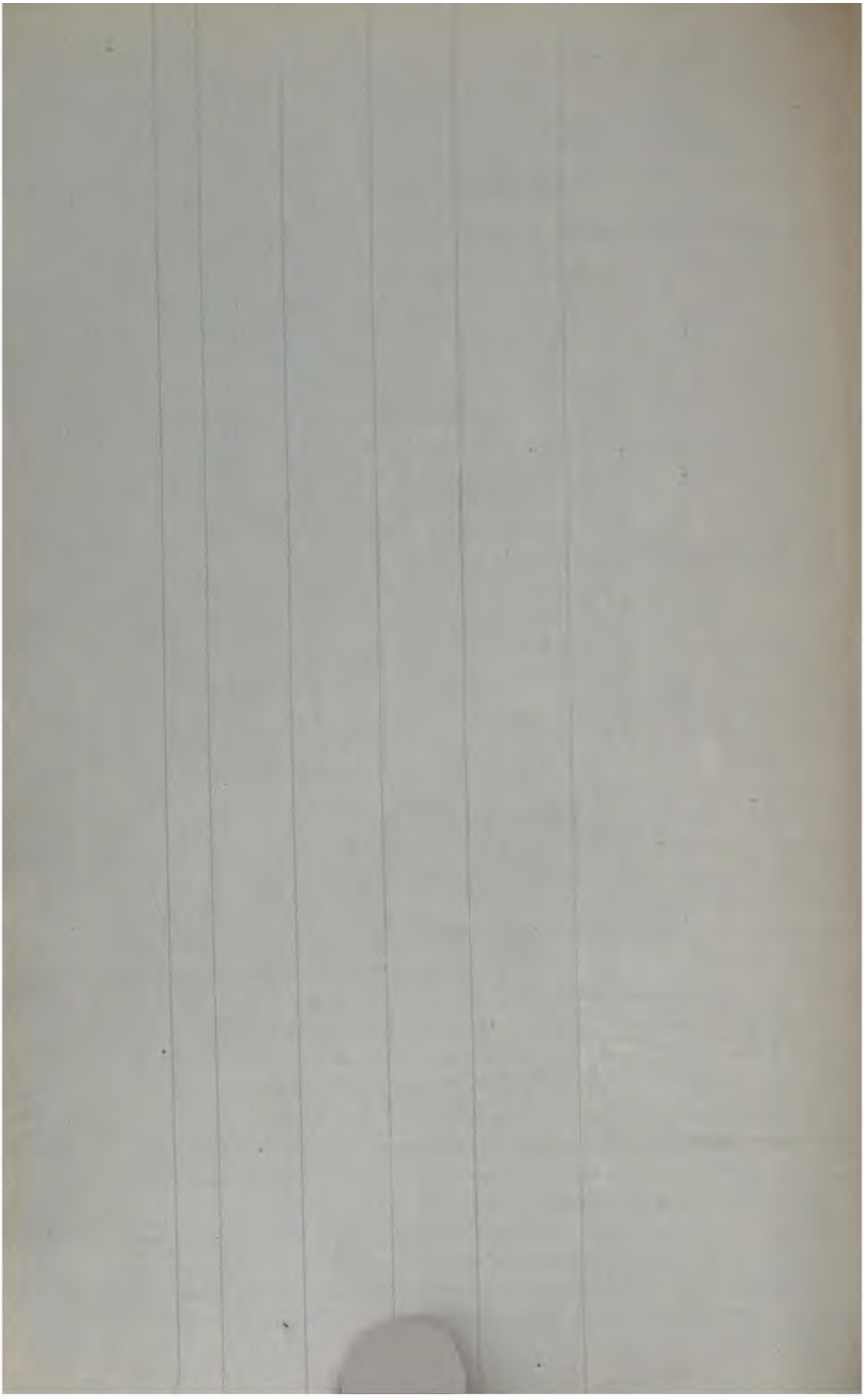
Width on each side of centre line.

[illegible] Drawing No. 12

[illegible] No. 1. [illegible]

[illegible]

superfic. yards.



EMBANKMENT No. 1.

No.	Widths.	Mean width.	Length.	Superfic. feet.
2	28′ 6″ 39 6	34′ 0″	198′ 0″	
2		39 6	66 0	
2	39 6 28 6	34 0	132 0	

CUTTING No. 2.

2	28 6 42 6	35 6	198 0	
2	42 6 48 6	45 6	66 0	
2	48 6 52 6	50 6	132 0	
2	52 6 50 6	51 6	132 0	
2	50 6 42 6	46 6	132 0	
2	42 6 28 6	35 6	132 0	

superfic. yards.

EMBANKMENT No. 2.

2	28 6 32 6	30 6	66 0	
2	32 6 28 6	30 6	66 0	

CUTTING No. 3.

2	28 6 64 6	46 6	330 0	

NOTE.—The figures in the first column are taken from the plan; but when the means are found and placed in the next column, the pen should be run through the first, leaving the remainder for admeasurement, as thus :—$2 \times 41' 6'' \times 66' 0'' = 5478$ superficial feet.

SOILING. DRAWING No. 12.

CUTTING No. 1. Begin A. Slopes 2 to 1.

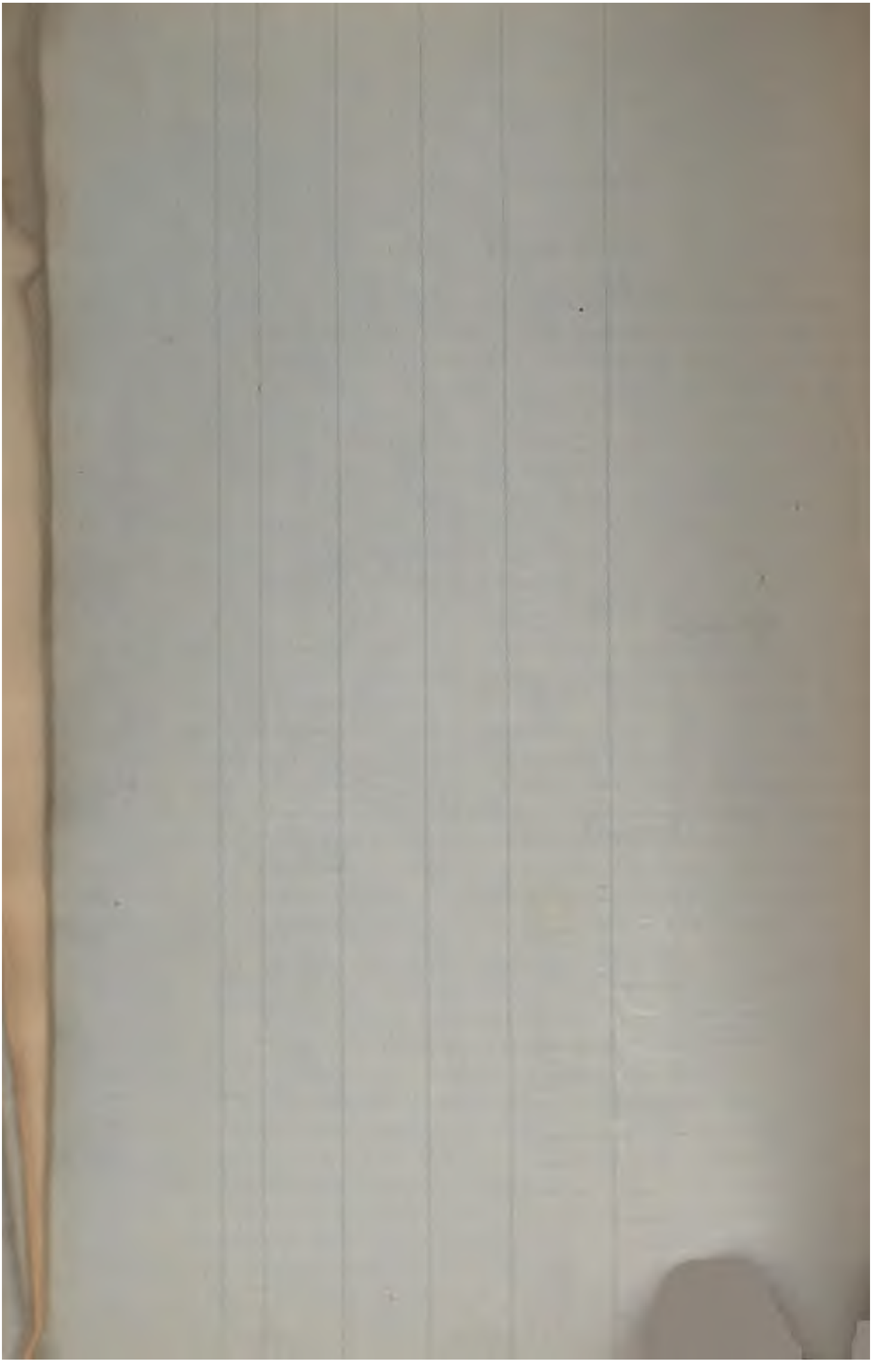
No.	Vertical height	Means	Slopes	Length	Sup. feet
2	7 0 6 0	6 6	14′ 6″	66′ 0″	1914 0
2	6 0 5 0	5 6	12 3	66 0	
2	5 0 5 0	5 0	11 2	66 0	
2	5 0 4 0	4 6	10 1	66 0	
2	4 0 3 0	3 6	7 9	66 0	
2	3 0 1 0	2 0	4 6	66 0	
2	1 0 0 0	0 6	1 1½	66 0	
					superfic. yards

EMBANKMENT No. 1.

2	5 6 5 6	5 6	12 3½	198 0	
2	5 6 5 6	5 6	12 3½	66 0	
2	5 6 0 0	2 9	6 2		

CUTTING No. 2.

2	7 0 10 0	8 6		198 0	
2	10 0 12 0	11 0		66 0	
2	12 0 11 0	11 6		132 0	
2	11 0 7 0	9 0		132 0	
2	7 0 0 0	3 6		132 0	



the centre line on each side, is the width required. On the same sheet are enlarged sections of banks and ditches, with dimensions, and method of formation.

Drawing No. 14 is one mile and a half of part of the plan of the Syston and Peterborough Railway, to show how the off-sets from the chord to the curve may be taken from the plan, booked and worked from in the field.

NOTE.—The faint lines are the chord lines and the sets off to the curve. Poles must be erected at every intersection, to form a straight ranging line for the chord of the curve to be measured, to set off the various distances at each chain, to the points for the stakes to be driven to form the curve. At first, at least until well practised in setting out curves, a chord of much less length should be measured, particularly when the radius is so small; as 20 chains, the length of the tangent should not exceed 4 chains, making a chord of 8 chains; and when the radius is extended to three miles, the length of the tangent may extend to 8 or 10 chains, the chord being twice that length.

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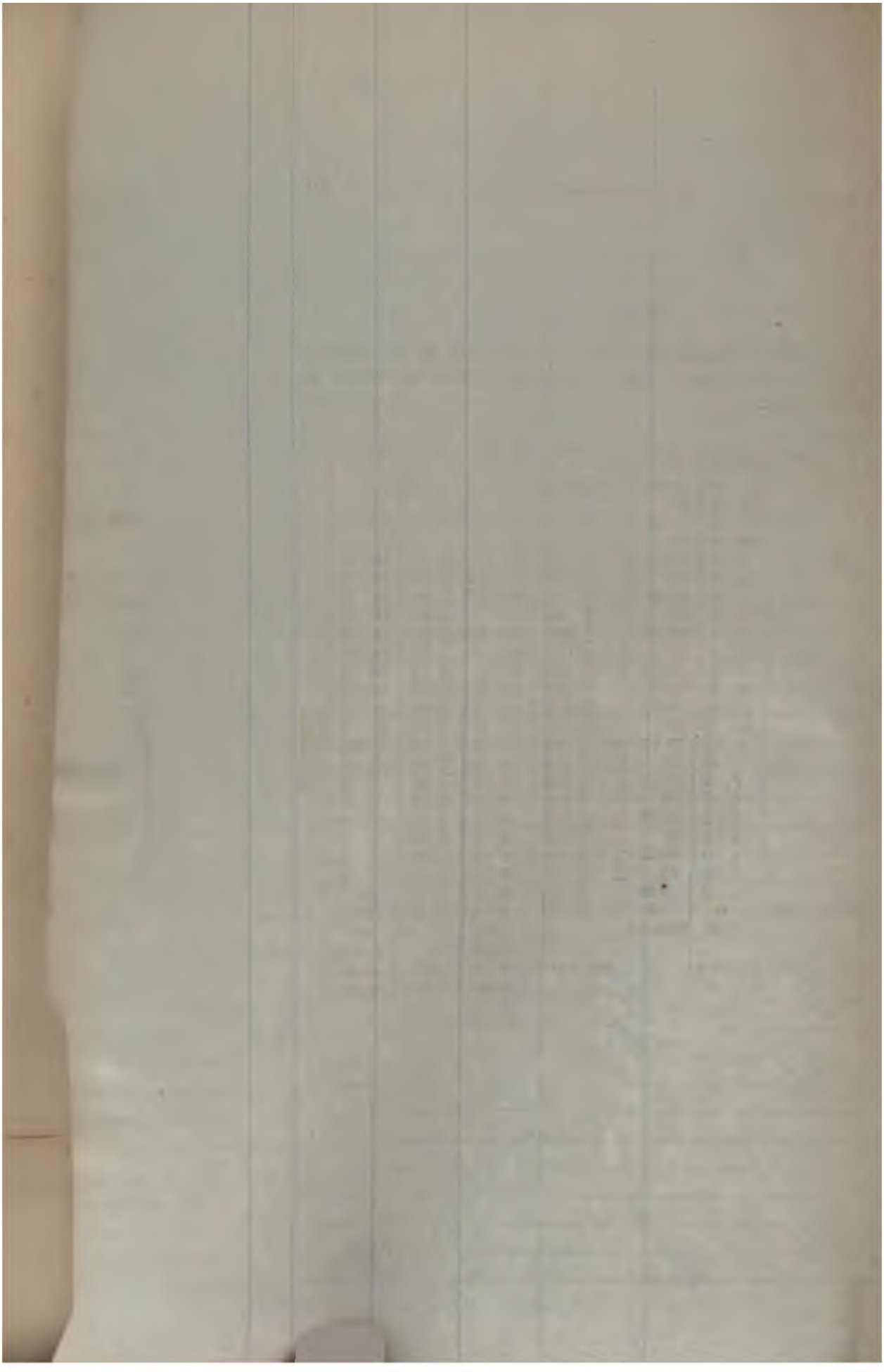


Drawing No. 14.

Note.—In placing the stakes at the different points for the embankment, &c., care must be taken to adjust the level or inclination, as the case may be.

Ch.	Lin.	Links.	Links.	Ch.	Lin.	Links.	Ch.	Lin.	
24	0	0							
23	0	9 25							
22	0	25							
21	0	39.25	0	22	0				
20	0	52	31	21	0				
19	0	63.25	40	20	0	0	19	0	
18	0	73	67	19	0	17	18	0	
17	0	81.25	82	18	0	32	17	0	
16	0	88	95	17	0	45	16	0	
15	0	93.25	106	16	0	56	15	0	
14	0	97	115	15	0	65	14	0	
13	0	99.25	122	14	0	72	13	0	
12	0	100	127	13	0	77	12	0	
11	0	99.25	130	12	0	80	11	0	
10	0	97	131	11	0	81	10	0	
9	0	93.25	130	10	0	82	9	50	half-chain.
8	0	88	127	9	0	81	9	0	
7	0	81.25	122	8	0	80	8	0	
6	0	73	115	7	0	77	7	0	
5	0	63.25	106	6	0	72	6	0	
4	0	52	95	5	0	65	5	0	
3	0	39.25	82	4	0	56	4	0	
2	0	25	67	3	0	45	3	0	
1	0	9.25	40	2	0	32	2	0	
0		0	31	1	0	17	1	0	
6	50	Straight.	0	0		0	0		
Begin A.			2nd curve.	Begin at 24 chains.		3rd curve.	Begin at 46 chains.		

Begin curve

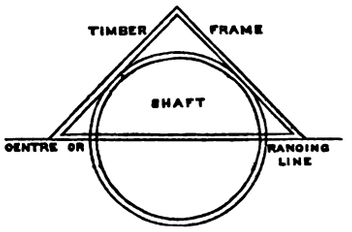
Links set off every chain to the right from chord.

Links set off to the left every chain from chord.

Links set off to the left every chain from chord.

TUNNELLING.

PREPARATORY to driving the ranging line for a tunnel, a spot should be chosen upon the centre line of the works, upon permanent ground, and in such situation as to command a view of some conspicuous object upon the centre line of the tunnel, but at some distance from the entrance. Upon this permanent spot a brick pier should be erected firmly, upon which to fix the transit instrument, which must be carefully adjusted, so that both the objects may be visible from it, to make upon them the mark for the ranging line; this brick pier should be sheltered from the weather by a temporary building, but such building must not touch the brick erection. From this the ranging line can be staked by signal as usual, and the centre of every shaft marked; and from such centre mark of the shaft bench-marks at some distance on each side should be made, or small piles driven, to mark or measure off at any time the centre of the shaft. When the shafts are sunk to the proper depth, if a plank be placed across the opening, the edge of which to be exactly touching the centre, and made to range, by adjustment with the instrument, with the ranging line, and two lines with heavy plumbs be dropped at each end of the plank, as near to the brickwork as convenient; when at rest a line drawn from plumb to plumb will give the ranging line at the bottom of the tunnel, which should be tested at every shaft. In many cases a triangular frame of timber is erected at such height as not to interfere with the works in progress, but so fixed that one side of the triangle, when adjusted by the instrument, should range exactly with the centre line of the tunnel, thus,—



from which the line can be transferred to the bottom of the shaft, although in windy weather some difficulty may be found in keeping the lines steady. The lines should be dropped in every shaft, and if a heading be driven, finally adjusted from one to the other throughout.

LIST OF PLATES.

G. Woodfall and Son, Printers, Angel Court, Skinner Street, London